Time Scales for Sustainable Urban System Design

- Stretching the Boundaries of Standard Practice

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Zusammenfassung

Einleitung und Kontext

Die vorliegende Doktorarbeit geht davon aus, dass Zeit ein kulturelles Artefakt ist und dass die deutliche Zunahme des Interesses von Experten an Nachhaltigkeit und nachhaltiger Entwicklung die Notwendigkeit widerspiegelt, kulturelle Normen zur Bewertung und Kommunikation von temporalen Eigenschaften sozialer Realität neu zu ordnen. Obwohl der Mensch die immanente Fähigkeit besitzt, Zukunft zu planen und sich vorzustellen, muss sich die Menschheit erst seit kurzem mit einer langfristigen, komplexen und äußerst unsicheren Zukunft als Teil einer fortgesetzten Gegenwart auseinandersetzen.

Entscheidungen können heutzutage erhebliche – manchmal irreversible – globale Auswirkungen über Zeithorizonte hinaus haben, die traditionell nur im Kontext ewiger Zyklen und göttlicher Daseinsformen betrachtet wurden.

Trotz des verlängernden Arms menschlicher Intervention ist offensichtlich, dass viele zeitgenössische Einflüsse die Horizonte von Entscheidungsprozessen sogar verkürzen. Man bedenke nur den Zerfall von Familien- und Gemeinschaftswerten in einer Welt, die immer urbaner und globaler wird; oder die Ablösung von Werten wie Genügsamkeit und Opferbereitschaft für himmlischen Lohn durch wirtschaftlichen Materialismus und nachfrageorientierte Ökonomie; oder die Ersetzung des Sozialvertrags und klassenbasierter Machtstrukturen vorindustrieller Zeiten durch eine Politik der Versprechen, in der Stimmen von Wechselwählern mit besonderen Interessen alle 3 bis 4 Jahre gewissermaßen ‚gekauft' werden. Es ist ein schmerzliches Paradox moderner Kultur, dass genau in der Zeit, in der die Menschheit die Zukunft am meisten beachten und wertschätzen sollte, so viele Kräfte in die entgegen gesetzte Richtung zu streben scheinen.

Besonders bedeutsam ist die Beziehung zwischen Zeitkonzepten und der gebauten Umgebung. Nachhaltige Entwicklung im 21. Jahrhundert ist in hohem Maße eine Frage dessen, wie Gesellschaften ihre gebaute Umgebung entwerfen und erhalten und wie sie die ökologische Basis erneuern, von der sie abhängig sind. Die kommenden Jahrzehnte werden Zeuge einer beispiellosen Investition in die gebaute Umgebung und besonders in die städtischen Infrastruktursysteme werden. Schätzungen zufolge sollen jährlich Billionen von Dollar investiert werden, nur um die wichtigsten Versorgungsdienste in Städten weltweit aufrecht zu erhalten. Wenn solche Investitionen ohne angemessene Beachtung der damit verbundenen Auswirkungen und unter Missachtung der langfristigen Kosten für Instandhaltung und Erneuerung getätigt werden, ist ein echter Erfolg in nachhaltiger Entwicklung nur schwer vorstellbar. Tatsächlich ist nachhaltige Entwicklung angesichts des Werts bereits existierender gebauter Ressourcen und des wachsenden Umfangs der damit verbundenen Bewegungen und Einwirkungen zum Großteil eine Übung darin, die konservative Veränderung von Gebäuden und städtischen Systemen zu lenken.

Wenn langfristiges Denken die Herausforderung und Urbanisierung die Bedrohung ist, wird letztlich jeder, der mit der Entwicklung der gebauten Umgebung zu tun hat, vom einzelnen Gebäude bis hin zu ganzen Stadtsystemen, den Begriff von Zeit überdenken müssen.

Diese Arbeit untersucht hauptsächlich drei Fragen: Erstens, inwiefern beeinflussen Zeitkonzepte die Art und Weise, in der eine Gesellschaft städtische Systeme baut? Diese Frage wird in drei Teilen untersucht: Was meinen wir, wenn wir von Zeit sprechen, und wie verändert sich dieser Zeitbegriff? Welche Beziehung besteht zwischen Zeitkonzepten und der Natur gebauter Umgebungen? Und welche analytischen Methoden können helfen, neue, nachhaltigere Konzepte von Zeit in die Entwicklung des öffentlichen Raumes zu integrieren?

Zweitens, welchen Einfluss haben erweiterte Zeithorizonte und neue Zeitkonzepte auf unser Verständnis nachhaltiger urbaner Systeme? Auch diese Frage hat drei Teile: Beeinflussen neue Zeitkonzepte unsere Fähigkeit, städtische Regionen im Sinne einer effizienten Nutzung von Ressourcen zu planen? Beeinflussen neue Zeitkonzepte unsere Fähigkeit, Risiken abzuwägen und städtische Regionen so zu sichern, dass sie zukünftige Erschütterungen und Überraschungen unbeschadet überstehen können? Wie beeinflussen neue Zeitkonzepte die Struktur von Entwicklungsteams, ihren Handlungsspielraum und den Entwicklungs- und Entscheidungsprozess?

Drittens, was geschieht in jedem einzelnen Stadium des Entwicklungsprozesses, wenn neue Zeitkonzepte eingeführt werden? Diese

Frage wird anhand angewandter Forschung von drei Seiten beleuchtet: Wie beeinflussen Zeitskalen den übergreifenden konzeptionellen Rahmen, den Entwicklungsteams für die Organisation ihrer Arbeit nutzen? Welche Veränderungen treten als Ergebnis erweiterter Zeithorizonte bei der Zusammenstellung der Akteure und bei Entwicklungs- und Entscheidungsprozessen auf? Und schließlich: Welche neuen 'Timing Tools' können Stadtentwicklern helfen, die Komplexität erweiterter Zeithorizonte und die fehlende Vertrautheit im Umgang mit neuen Zeitkonzepten zu meistern?

Methoden

Neben einer Literaturauswertung wurden auch Workshops, Entwurfsübungen, Modellerstellungen, vergleichende Analysen und Visualisierungen durchgeführt. Die angewandte Forschung begann mit der Definition eines allgemeinen Bezugsrahmens – dem SEEIM Framework – der für den Entwurf urbaner Systeme gedacht ist. SEEIM steht für Scoping (Grenzen abstecken), Envisioning (gedankliche Konzeptionierung), Exploring (Erforschung), Implementing (Umsetzung) und Monitoring (Überwachung). Dieses System bildete die Basis zur Strukturierung der Forschung wie auch der Dokumentation.

In einem intensiven dreitägigen interdisziplinären Workshop wurden hypothetische Entwürfe für urbane Regionen erstellt und die wichtigsten Konzepte und Prinzipien eines langfristigen integrierten Systemdesigns. Die Arbeit an einem hypothetischen Entwurf resultierte in einer empirischen Fallstudie, im Rahmen derer der Autor Expertengruppen leitete, Reports erstellte und eine Reihe von öffentlichen Veranstaltungen durchführte. Ergebnis all dieser Aktivitäten war der Entwurf für ein langfristig angelegtes urbanes System für eine bereits existente Stadtregion: der Großraum Vancouver. Die Fallstudie wurde Teil eines öffentlichen regionalen Planungsprojekts für den Großraum Vancouver, der *Sustainable Region Initiative*. Darüber hinaus floss sie in den langfristig angelegten Entwurf CitiesPLUS für Vancouver ein, der letztlich als Wettbewerbsbeitrag an der Ausschreibung *Sustainable Urban System Design* der International Gas Union teilnahm.

Die Fallstudie zum Großraum Vancouver dauerte zwei Jahre und bot die Gelegenheit, den Prozess eines langfristig angelegten Entwurfs genau zu beobachten und aus erster Hand zu dokumentieren, wie Änderungen an Zeitskalen und anderen Systemgrenzen in Kombination mit einem stärker interdisziplinär orientierten und integrierten Entwicklungsprozess die Ergebnisse in jeder Schicht des SEEIM Framework beeinflussen.

Der Umfang der Feldarbeit bot außerdem die Gelegenheit, eine Reihe neuer Konzepte und Timing Tools in der Realität zu testen. Diese Tests wurden als Einzelexperimente in die größere Fallstudie eingebettet und boten die Möglichkeit, Methodologien zu erforschen und zu vergleichen. Die Methodik der Fallstudie selbst ist eines der Ergebnisse der Forschungen – eine einzigartige, felderprobte Vorlage zur Operationalisierung langfristiger urbaner Systementwicklung auf regionaler Ebene.

Der Umfang der Feldforschung erforderte die Mitarbeit von interdisziplinären Teams aus Forschern und Beratern, die an der angewandten Forschung für die Entwicklung urbaner Systeme teilnahmen, einschließlich Workshops und Charrettes. Insgesamt nahmen ungefähr 500 Experten, Akademiker und Regierungsbeamte an den Workshops, Symposien, Forschungsprojekten und Charrettes teil. Darüber hinaus bot die Fallstudie die Gelegenheit, mit einer Vielzahl von internationalen Teams, die an ähnlichen Projekten arbeiten, zu interagieren und ihre Ergebnisse zu Stadtregionen auf verschiedenen Kontinenten zu vergleichen. Follow-Up-Workshops und Charrettes wurden mit ähnlichen Teams von Stadtentwicklern in Indien, China, Europa und Japan durchgeführt.

Theorie

Gebaute Umgebung diente schon immer dazu, kulturelle Zeitkonzepte zu festigen und dadurch Richtung und Ablauf von Veränderungen zu lenken. Sie kann auch dazu dienen, Individuen im endlosen Zeitfluss Orientierung zu bieten, und der Gesellschaft gleichermaßen Uhr und Spiegel zu sein. Einige Aspekte zeitgenössischer Planung und Entwicklung neigen dazu, Bilder der Vergangenheit und der Zukunft zu verschmelzen und durcheinander zu werfen. Die Architekturstile moderner Städte stammen beispielsweise oft aus unterschiedlichen Epochen und Regionen. Planungshorizonte und Erneuerungsraten weisen so gut wie keine Ähnlichkeiten mit der tatsächlichen Lebenszeit von Stadtsystemen auf.

Langlebige Elemente sind nicht im Hinblick auf zukünftige ungewisse Bedingungen ausgelegt, unter denen sie funktionieren müssen. Design-Berufe scheinen wenig darauf vorbereitet zu sein, sich den unausweichlichen Veränderungsprozessen wie Witterung, Angleichung und Erneuerung zu widmen.

Teil einer Lösung könnte ein Ansatz sein, der die Mitwirkung und Zielsetzung durch die Gemeinschaften mit einer langfristig angelegten, integrierten räumlichen und physikalischen Modellerstellung kombiniert. Die regionale Ebene scheint sich hierfür besonders gut zu eignen, wobei viel Flexibilität für die Festlegung angemessener Grenzen für eine Region erforderlich sein dürfte. Im Idealfall erlaubt ein regionaler Ansatz die Einbeziehung der längeren Zyklen der natürlichen Umgebung, von der kleine und große Städte abhängig sind. Die regionale Ebene bietet außerdem die Möglichkeit, die Komplexität zu reduzieren, indem Entwickler die Perspektive nur eines Systems annehmen und sich langsam bewegende Elemente wie das lokale Infrastrukturnetz und die natürlichen Systeme mit einbeziehen, von denen städtische Zentren abhängen.

Decision Support Systems scheinen ein besonders wichtiges Mittel zu sein, um die zusätzliche Reichweite und Komplexität nachhaltiger Entwicklung urbaner Systeme auf regionaler Ebene zu bewältigen. Historische Fehlschläge mit computerbasierten Modellen und die derzeitig geringen Benutzerraten legen nahe, dass Design Tools eine besondere Herausforderung darstellen. Zurzeit scheint kein solches Werkzeug gut mit Systeminteraktion im Zeitablauf oder mit veränderten Zeitpräferenzen umgehen zu können.

Die Grundsätze ökologischer Planung liefern eine breite Palette an Leitlinien und Arbeitsbeispielen, die zeigen, wie Systeme langfristig effizient funktionieren können. Aus dieser Perspektive gesehen scheint eine Entwicklung urbaner Regionen zu urbanen Ökologien erforderlich – zu zellularen, vielschichtigen Strukturen, in denen die gesamte Infrastruktur zu einem einzigen undifferenzierten System verschmilzt, das weit verzweigt, aber in sich verknüpft, integriert und anpassungsfähig ist, geringe Auswirkungen hat, dienstleistungsorientiert, selbstorganisierend und vielseitig ist. Ein ökologischer Entwurf kann auch als Leitfaden für die Entwicklung urbaner Systeme im Zeitablauf – nämlich durch Sukzession und Adaption – dienen, um sie effizienter und resistenter zu machen.

Eine langfristige Betrachtungsweise, die auch Zyklen und Muster berücksichtigt, kann ebenfalls dabei helfen zu definieren, wie sich urbane Systeme verändern werden. Historisch gesehen sind Energiequellen und Technologien möglicherweise die bedeutendsten Faktoren, die Form, Größe, Dichte, Lage und Wohlstand von Städten beeinflussen. So gesehen scheint es wahrscheinlich, dass aktuelle Trends in der Energietechnologie über die kommenden Jahrzehnte zu einem radikalen Wandel in der Entwicklung von Stadtregionen führen werden. Große monozentrische Stadtregionen können in weit verstreute autarke Cluster-Siedlungen zerfallen, die über offene Netzwerke verbunden sind, die auf lokaler Ebene engmaschiger und komplexer sind. Diese Trends einschließlich der ‚S'-Kurven bei innovativen Technologien zu verstehen, kann für eine langfristige Funktionalität in der urbanen Systementwicklung von entscheidender Bedeutung sein.

Eine ökologische Stadtentwicklung scheint eine positive, langfristige Perspektive zur Beseitigung von Umweltschutzauflagen durch effizientere und anpassungsfähigere Entwürfe auf Systemebene zu bieten. Sie kann außerdem als wissenschaftliche Basis für eine nahtlosere Integration von Zeitfaktoren in die Architektur und Stadtplanung dienen. Besonders bei einer langfristigen Betrachtungsweise ist es schwer, die wachsende Vielfalt und Häufigkeit von Erschütterungen zu ignorieren, die Stadtsysteme sowie die dynamische Beziehung zwischen Nachhaltigkeit und Widerstandsfähigkeit beeinflussen.

Die Planung urbaner Widerstandsfähigkeit hat ihren Ursprung vermutlich in den Verteidigungssystemen antiker Stadtstaaten. In jüngerer Zeit scheinen sicherheitspolitische Grundsätze einen ganzen Zyklus von nationaler Sicherheit, der Sicherheit des Einzelnen, über die häusliche Sicherheit und wieder zurück zur Sicherheit von Städten durchlaufen zu haben. Im Allgemeinen scheint die Annahme begründet, dass die Anfälligkeit für alle möglichen Risiken parallel zur Urbanisierung zunimmt und die Zukunft von einer Vielzahl städtischer Desaster sowie von gesellschaftlichem Zerfall geprägt sein wird. Dies könnte ein bezeichnendes Merkmal des kommenden Jahrhunderts sein.

Durch die Globalisierung wuchs die Verflechtung städtischer Regionen stark an und die Notwendigkeit von Voraussicht und Notfallplanung erhöhte sich. Die Sicherheit einer Stadtregion ist heute wohl untrennbar mit der Nachhaltigkeit ihrer wichtigsten Handelspartner verbunden. Um überleben zu können, müssen städtische Regionen eine Vielzahl von globalen Partnerschaften knüpfen und den Rahmen ihre Notfallplanung und Finanzreserven vergrößern. Selbst ohne die handelsbedingten Abhängigkeiten stellt die Möglichkeit des Kollabierens von Megastädten in den Entwicklungsländern eine große Bedrohung für städtische Regionen in anderen Teilen der Welt dar.

Entscheidend wichtige Infrastruktursysteme werden bisher nicht gut verstanden, wobei die Reichweite dessen, was als entscheidend angesehen wird, immer größer wird. Auch die Komplexität nimmt zu und wird zu einer immer größeren Herausforderung werden, wenn städtische Regionen einem zunehmend ökologischen Entwicklungsansatz folgen.

Seit einiger Zeit wird einer Notfallplanung, die sich auf die langfristige Widerstandsfähigkeit von wichtigen Infrastrukturen konzentriert, mehr Aufmerksamkeit geschenkt. Dennoch ist der Schwerpunkt in Forschung und Diskussion noch auf Reaktion und Wiederherstellung begrenzt, trotz solcher Begriffe wie ‚katastrophenresistente Gemeinschaften'.

Erweiterte Zeitskalen ermöglichen eine größere Anzahl von Entwurfslösungen, die nur selten oder nie von konventionellen Notfallplanern in Betracht gezogen werden. Genauer gesagt wird es möglich, Risiken in der Landschaft einer Region abzubilden und Wege zu erforschen, die die Anfälligkeit von langlebigen Elementen des städtischen Systems reduzieren: Gebäude, öffentliche Wege und institutionelle Strukturen. Möglicherweise wird auch eine Kultur des ‚vorbereitet Seins' entstehen, die sich von Individuen, Familien und privaten Unternehmen bis zu öffentlichen Institutionen und der Gemeinschaft als Ganzem erstreckt. Städtische Regionen werden ‚lernfähige Systeme' wie beispielsweise anpassungsfähiges Management benötigen, Systeme also, die auf Überraschungen und Fehlschläge eingerichtet sind. Solche Systeme sind flexibel, haben keine Strukturen, kein festes Zentrum, und enthalten übergreifende Netzwerke und Feedbackschleifen für aktives Lernen und Flexibilität. Zukünftig kann die Fähigkeit zu lernen und flexibel zu planen eine ‚Quelle der Erneuerung' sein, die eine erfolgreiche Anpassung von Systemen an Erschütterungen und Überraschungen ermöglicht.

Den Faktor der Unsicherheit in Szenarien von Lebenszyklen einzubinden, kann eine bedeutende Herausforderung darstellen, insbesondere im Zusammenhang mit der großen Unsicherheit längerfristiger Zeithorizonte. Möglicherweise kann die Langlebigkeit von Systementwürfen mit einfachen, vernünftigen Entwurfsprinzipien in Beziehung gesetzt werden. So können beispielsweise weniger Abhängigkeiten innerhalb eines Systems seine Anfälligkeit verringern. Generische Entwürfe mit flexiblen Merkmalen können die Anpassungsfähigkeit steigern. Und typische Überlebensmerkmale aus der Geschichte können das Überleben von Systemen auch in der Zukunft sichern helfen. Die ökologische Theorie besagt, dass Überlebensfähigkeit auch mit Entwicklungskonzepten wie Modularität, Redundanz und Selbstorganisation in Verbindung stehen könnte.

Zu den treibenden Kräften, die Stadtregionen im Lauf des nächsten Jahrhunderts vermutlich verändern werden, zählen Naturkatastrophen, der Klimawandel, demographische Aspekte, verschiedene Weltbilder, die Globalisierung, technologische Veränderungen und die Verfügbarkeit von Ressourcen. Eine oberflächliche Betrachtung dieser Kräfte im Hinblick auf städtische Regionen legt nahe, dass die Geschwindigkeit, mit der Veränderungen auftreten, zunehmen wird, wodurch die Vielfältigkeit und Häufigkeit von Bedrohungen, Erschütterungen und Katastrophen zunehmen wird. Die meisten dieser entscheidenden Triebkräfte liegen zum Großteil außerhalb des Einflussbereiches lokaler Entscheidungsträger. Dennoch sollte es mit ausreichendem Weitblick möglich sein, urbane Systeme zu planen, die weniger anfällig sind.

Um widerstandsfähige Planungslösungen für städtische Regionen entwickeln zu können, bedarf es eines permanenten lokalen Informationsaustauschs, der Szenarienentwicklung und neuer Methoden und Werkzeuge für eine pro-aktive Sicherheitsplanung. Die Prüfung der Timing Tools, die Gemeinden und Planungsexperten zur Verfügung stehen, ergab eine reiche Auswahl an Werkzeugen, von denen viele eine potentielle Anwendung in der Stadtentwicklung finden könnten. Einige leistungsstarke analytische Methoden wie die Lebenszyklusanalyse (LZA) und die Materialflussanalyse (MFA) können ebenfalls zur Entwicklung effizienter und widerstandsfähiger regionaler Systeme beitragen.

Drei Zeitkonzepte scheinen besonders relevant für zukünftige Planungsmethoden zu sein: 1) **Zeitverlängerungen** können die kausalen Zusammenhänge zwischen aktuellen Bedingungen und vergangenen Handlungen offen legen und es Entwicklern ermöglichen, Trends vorauszusehen und Modelle für eine zukünftige Interaktion zu erstellen; 2) **Zeitringe** können dabei helfen, die unterschiedliche Lebensdauer von Elementen in einem System zu veranschaulichen und die Ausbalancierung und Koordinierung von Zeitskalen beim Planen und Gestalten zu ermöglichen; 3) **Zeitzyklen** können die Unausweichlichkeit sich verändernder Umstände verdeutlichen, so dass es Planern möglich wird, aus historischen Veränderungsmustern zu lernen. Diese neuen Perspektiven sind einfach und doch grundlegend in ihren potenziellen Auswirkungen auf die Methoden und Rahmenbedingungen der Entwicklung. Indem sie positive Synergieeffekte nutzen und einen systemischen Ansatz ermöglichen, erlauben sie die Operationalisierung eines stärker ökologisch und evolutionär ausgerichteten Ansatzes in der Entwicklung.

Darüber hinaus unterstreichen neue Zeitkonzepte, wie wichtig es ist, viele Akteure in einen gemeinschaftlichen, rationalen Planungsprozess einzubinden. Die Entwicklung urbaner Systeme auf kommunaler oder regionaler Ebene geschieht oft kurzfristig und wird von der Produktverfügbarkeit bestimmt. In Zukunft wird eine umfassendere Nutzung von rationalen, hierarchischen Rahmenbedingungen eines der ‚Timing Tools' darstellen, das für eine erfolgreiche langfristige Planung erforderlich ist, insbesondere angesichts der Komplexität urbaner Systeme und der Anzahl von Entscheidungsträgern. Trotz einer Vielzahl von Innovationen seit den 1950er Jahren scheint es zeitgenössischen Rahmenwerken für Stadtplanung an Transparenz und Stärke zu mangeln. Zwei der viel versprechendsten Prozesse sind hierbei die integrierte Entwicklung und die gemeinschaftliche Entscheidungsfindung. Auf Kooperation beruhende Prozesse scheinen besonders dort für die Stadtplanung geeignet zu sein, wo technische und politische Prozesse miteinander koordiniert werden müssen und wo Komplexität and Risiken eher traditionelle Entscheidungsträger abschrecken.

Wesentliche Ergebnisse

Wie anhand eines einzigen detaillierten Beispiels deutlich wird, scheinen Zeitkonzepte einen erheblichen Einfluss auf den Entwicklungsprozess, die Zusammensetzung von Planungsteams und den Umfang des Entwurfsprogramms zu haben. Vergleiche mit internationalen Fallstudien haben einige der positiven Einflüsse bestätigt – insbesondere die Synergie zwischen neuen Zeitkonzepten und ökologischen Modellen.

Das fünfschichtige ‚SEEIM'-Framework erwies sich als geeignet für die Zusammenstellung und Leitung kooperativer Planungsteams und die Entwicklung integrierter langfristiger Planungslösungen. Dennoch wurden auf jeder Stufe des Rahmenwerks neue Werkzeuge benötigt. Sie dienten sowohl der Verbesserung der Kommunikation als auch zur Bewältigung der Komplexität – beides Faktoren, die immer schon zur Frustration von Planungsteams beigetragen haben, die aber besonders problematisch erscheinen, wenn neue Zeitkonzepte eingeführt werden. Das erweiterte Rahmenwerk und die zugehörigen Werkzeuge scheinen übertragbar und somit offen für Weiterentwicklungen zu sein, um so auch in anderen städtischen Regionen einsetzbar zu sein.

Eine bidirektionale Zeitskala ist beispielsweise ein einfaches Werkzeug, um politische und technische Rationalität zu verbinden: langfristige Zukunftsvisionen können eindeutig mit historischen Stärken, Werten und Überzeugungen verbunden werden. Erweiterte Zeithorizonte ermöglichen die Inszenierung des Umgestaltungsprozesses oder -pfades und dienen dazu, utopisches Planen auf die moderneren Methoden der Stadtentwicklung abzustimmen. Eine 'Szenarien-Landkarte' oder ein ‚Scenario Wheel' wurden dazu benutzt, die Szenarienplanung in die Zeitringe zu integrieren und deutlich zwischen kurzfristigen und langfristigen Szenarien sowie zwischen Methoden des Change Management und der Vorhersage zu unterscheiden. Ein ‚kaleidoskopischer Ansatz' wurde entwickelt, um die komplexe Kategorisierung städtischer Systeme zu meistern und trotz Einbeziehung mehrere Disziplinen und Vorgehensweisen den Zusammenhang zu wahren. Dieser Ansatz unterstreicht, wie wichtig es ist, Systeme über die verschiedenen Ringe der Zeit und der Nachhaltigkeit hinweg auszubalancieren und die Verfahrensweisen mit denselben fünf Schichten des SEEIM-Frameworks zu verbinden.

Aus integrierten Planungsprozessen in Kombination mit gemeinschaftlicher Entscheidungsfindung wurde ein ‚PLUS'-Modell erstellt, das auf jede Region anwendbar ist. Das PLUS-Modell besteht aus vier Bereichen – einem akademischen, einem staatlichen, einem privaten, und einem bürgerlichen Sektor – über eine Reihe von konzentrischen Kreisen der Verantwortlichkeiten, von politischer bis zu technischer Verantwortung. Bei der Entwicklung des Pfades wurde ein ‚Ein-System'-Ansatz angewandt, der verschachtelte Skalen für Zeit und Raum hintereinander mit drei operativen Grundsätzen kombiniert: (1) Synchronisation, oder die Bewegung von langsamen zu schnellen Ringen; (2) Lokalisation, oder die Entfernung von der lokalsten Skala ausschließlich zum Zweck der Effizienzsteigerung; und (3) Synergisierung, oder die Bewegung von der Makro- oder regionalen Skala zur lokalen Skala mit Hilfe von Zielvorgaben und Ermächtigungsstrategien.

Wiederholt wurde eine ‚Systems Design'-Charrette eingesetzt, um den Herausforderungen der Entwurfsintegration zu begegnen. Die SD-Charrette richtet anders als andere Workshops zur Stadtplanung einen besonderen Schwerpunkt auf die Inszenierung langfristiger Pfade, auf die Dynamik urbaner Systeme und auf die Erhaltung ökologischer Funktionen. SD-Charrettes erfordern im Voraus durchgeführte Studien und eine breiter gefächerte Orientierung der Teilnehmer und können von anderen Werkzeugen zur Bewältigung der Komplexität in jeder Schicht des SEEIM-Frameworks profitieren.

Eine Reihe bestimmter Planungswerkzeuge erweisen sich im Umgang mit Komplexität als besonders effektiv. Ziele für einen ‚Endzustand' wurden definiert, die langfristige Zielvorgaben darstellen, indem sie den gewünschten Endzustand oder die letztlich angestrebte Richtung beschreiben. ‚Benchmarking Scales' erwiesen sich als nützliches Werkzeug, um Indikatoren und Zielsetzungen in einem nicht-technischen Format einzuführen. Eine Reihe von ‚Kernindikatoren' wurden zur Systematisierung und Standardisierung von Materialflussanalysen erstellt. Die Planung von ‚Solution Space' war ein nützliches Werkzeug, um die Bedeutung der Veränderungsgeschwindigkeit zu verstehen. Ein Solution Space definiert einen Akzeptanzspielraum in Relation zu quantifizierbaren Leistungsmaßstäben. Er wird durch einen kritischen Pfad sowie durch einen bevorzugten Pfad begrenzt, die beide so angelegt sind, dass sie den angestrebten Endzustand erreichen.

Ein Software Tool für die schnelle Erstellung von Sankey-Diagrammen (gerichtete Flussdiagramme) wurde entwickelt. Dieses Tool enthält eine Methode zur Standardisierung von graphischen Begriffen und Formaten, so dass Sankey-Diagramme in allen Maßstäben benutzt werden konnten, vom Gebäude bis hin zur Region. Dies ermöglichte den Einsatz von Sankey-Diagrammen zur Darstellung und zum Vergleich vielfältiger Dynamiken innerhalb urbaner Systeme. Auch dienten sie zur Zusammenfassung verschiedener Leistungsindikatoren in einzelnen, einfach zu lesenden Graphiken. Sankey-Diagramme wurden zum wichtigsten Werkzeug für den Vergleich verschiedener Standorte und die Entwicklung neuer Szenarien.

Zur Unterstützung von Analysen und zur Entwicklung von Szenarien in interdisziplinären Workshops wurden auch traditionelle Einflussdiagramme eingesetzt. Außerdem wurden ‚Einfluss-Interventionsdiagramme' entwickelt und auf alle Arten von urbanen Bedrohungen und Systemen angewandt. Ein weiteres Werkzeug wurde entwickelt, um archetypische Darstellungen von Katastrophen – Naturkatastrophen, sozioökonomische Desaster, Versorgungsengpässe, Übergänge in der Marktnachfrage – zu erstellen und diese als Szenarien für die Entwicklung von Systemen zu verwenden, die Erschütterungen testen sollen.

Die Erstellung von ‚Katalysator-Interventionen', einer separaten Gruppe von Strategien, Grundsätzen und Projekten, die Aktionen über multiple Systeme hinweg ausrichten, erwies sich als nützlich für die Integration langfristiger Pfade in die Fallstudie. Ein neues System zur Entscheidungsunterstützung, das ‚Sustainable Urban Metabolism Model' (SUMM), wurde zur Erstellung und Auswertung von Szenarien entwickelt. Das skalierbare Modell SUMM, auf das über das Internet zugegriffen werden kann, kombiniert die zuvor erwähnten Werkzeuge zur Visualisierung und Indikatorentwicklung mit zusätzlichen Werkzeugen zur Sammlungen, Aggregation und Analyse von Daten, alles integriert in einer GIS-basierten Plattform zur Entwicklung von Szenarien (Community Viz). Die größten Hindernisse für die erfolgreiche Anwendung von SUMM waren die begrenzte Datenverfügbarkeit und fehlendes Benutzertraining.

Alle Werkzeuge für die Entwicklung urbaner Systeme wurden letztlich in einem ‚adaptiven Managementsystem' zusammengefasst und in ein integriertes ‚Syntropic Design Framework' für die Entwicklung urbaner Systeme. Dieses syntropische Rahmenwerk bietet Planungsteams einen pluralistischen Ansatz, der jede einzelne Gruppe von Werten oder politischen Prioritäten integrieren kann, ohne dabei die Vorteile der rationalen Planung und der integrierten Systementwicklung zu verlieren. Mit dem Rahmenwerk wird versucht, die traditionellen Grenzen zwischen Raumplanung und Materialflussanalyse zu überwinden und einen gemeinsamen Prozess über erweiterte Zeitskalen einzubeziehen.

Abschlussbetrachtungen

Während der Untersuchung ergaben sich neue Fragen, die unter Umständen in interessante Richtungen für neue Studien weisen. Ist es wünschenswert, eine systemischere, visuellere und allgemeingültigere Gruppe von Begriffen und Bildern zu entwickeln, um die langfristige Leistung einzelner Elemente einer Region darzustellen? Brauchen Planer eine ‚Mustersprache' für Zeitlichkeit? Ist es möglich, nachhaltige Planungsergebnisse einfach dadurch zu erzielen, dass Planer und Entscheidungsträger sich am Kontext dessen orientieren, was bereits stattgefunden hat und wahrscheinlich langfristig stattfinden wird? Ist es möglich, für Regionen langfristig die finanziellen und personellen Ressourcen zu erhalten, die benötigt werden, um einen gemeinsamen Entwicklungsprozess aufrechtzuerhalten, angesichts der Tatsache, dass solche gemeinschaftlichen Prozesse außerhalb der Mandate und Budgets der einzelnen Akteure liegen?

Liegt die eigentliche Herausforderung angesichts der Geschwindigkeit von Veränderungen und der wachsenden Komplexität wichtiger Infrastruktursysteme in der Institutionalisierung eines fortgesetzten Lernprozesses? Wird eine integrierte Planung angesichts der sehr unterschiedlichen Verfahren und Denkweisen von Raumplanern und Systementwicklern jemals möglich sein? Muss der aktuelle Schwerpunkt von Gemeinden auf der Erhaltung des Erbes der Vergangenheit in einer Art und Weise neu definiert werden, dass ein ‚Futur Perfekt', eine Zukunft der Vergangenheit, eine Bewahrung der Zukunft mit eingeschlossen ist? Ist postmoderne Architektur einfach die Wiederentdeckung der Schönheit und Notwendigkeit einer Entwicklung ‚im Rahmen des Machbaren'? Und sind Zeitkonzepte einfach ein Bestandteil einer erneuerten Ästhetik, die auf Ethik und begrenzten Ressourcen beruht?

SETTING THE STAGE

Civilization is revving itself into a pathologically short attention span. The trend might be coming from the acceleration of technology, the short-horizon perspective of market-driven economics, the next-election perspective of democracies, or the distractions of personal multi-tasking. All are on the increase. Some sort of balancing corrective to the short-sightedness is needed - some mechanism or myth which encourages the long view and the taking of long-term responsibility, where 'long-term' is measured at least in centuries.*

Stewart Brand et al, "The Long Now Foundation" 2004

*"revving: an American term for increasing speed, or accelerating an engine

1 Introduction

1.1 Context

Sustainability and *sustainable development* are fuzzy terms that have evolved to embody a number of important concepts. Initially the focus was intergenerational equity, and resource conservation. With time their meaning has expanded to include preserving biodiversity, satisfying ecological carrying capacity, and allocating scarce resources fairly in a crowded world. While the evolution of word meanings can generate some confusion, it is also what continues to make these terms powerful and fresh for so many people. Discussions can start at any level of sophistication, and then extend to broader scope and emerging concepts. This thesis is intended to contribute, in a small way, to such an evolution in the concepts behind the terms. It will do this by addressing sustainability and sustainable development in their most fundamental sense, as terms that speak to our appreciation of time.

To be sustainable, there must be a "capability of being sustained" (Merriam-Webster). Sustainability thus implies persistence, longevity, and durability. It is about survival over the long-term. From this 'fundamentalist' perspective, the challenge of sustainable design is about long-term thinking. All else is derivative.

The thesis concludes that time is a cultural artefact, and that the explosion of professional interest in sustainability reflects a need for restructuring cultural norms for valuing and communicating temporal attributes of social reality. While human beings have an innate capacity to plan and imagine the future, only recently has it become essential for humanity to cope with long-term, complex and deeply uncertain futures, as part of an extended present. Decisions today can have substantial – sometimes irreversible – impact at global scale, over time horizons that would traditionally be considered only in the context of eternal cycles and the lives of gods.

Despite the lengthening arm of human intervention it is apparent that many contemporary forces are actually shortening decision-making horizons. Consider the erosion of family and community values in a world becoming more urban and more global; or how values like frugality, and sacrifice for heavenly rewards have been replaced by economic materialism and demand-side economics; or how the social contract and class-based power structures of pre-industrial times have been replaced by promissory politics, where votes are effectively 'purchased' every 3 or 4-years from swing voters with special interests. It is a poignant paradox of modern culture that at the very time when humanity most needs to consider and value the future, so many forces seem to be pushing in the opposite direction.

In a rapidly changing world it is perhaps not surprising that culturally-defined timing tools may have become ineffective or outdated. But what does this mean for the design profession? And more specifically, what kinds of innovations in timing – what new concepts, methods and tools for addressing time in design – might help us construct sustainable urban regions?

These are not insignificant questions. The built environment lies at the origin of a majority of the mass and energy flows directed by humanity. It absorbs large economic resources, and embodies considerable cultural capital. Although form and composition can vary from place to place, the built environment invariably constitutes a principal societal resource in the modern world. [KOHLER 05] From a pragmatic perspective, sustainable development in the 21st century is largely a question of how societies design and maintain the built environment, and regenerate the ecological support base upon which it depends.

In a rapidly urbanizing world, the built environment is mostly a synonym for cities and urban regions. The predominance of urban lifestyles has become a defining attribute of the modern era. It is worth recognising that the current scale of urbanization has been surprise to everyone, including town and regional planners. In 1800, only London and Peking may have had a population of more than 500,000. By 1935 Lewis Mumford, a great urban scholar and visionary who at that time was living in New York City with 7 million others, concluded that it would be impossible for the large new 'conurbations' to be sustained, given the abysmal quality of life, and the economic costs of heath care, policing, and moving goods and commuters. "The end of their reckless expansion is near." [MUMFORD 38] Yet by 2001 New York had grown to 16 million, there were over 400 cities with populations of over one million and 17 megacities with populations over 10 million (UN Secretariat 2002).

Something close to half of humanity now live in 'urban regions', and this process of urbanisation is expected to continue for another three decades. The UN now confidently predicts another 358 'million-cities' by the year 2015, and another 27 mega-cities. Today, once again, experts are predicting the size of cities will hit a limit imposed by logistics: managing the services, transport and waste. Some even foresee a disintegration of megacities due to diseconomies of scale, or water scarcities, or rising sea levels. However as Peter Hall and others recognise "Humanity has not been down this road before; there are no precedents, no guideposts." [HALL 2000]

So sustainability is in large part a challenge for urban design. The challenge is not new. Since the birth of civilization – a term for city-based cultures – the educated classes of society have been addressing methods for building durable, resilient and lasting cities and urban systems. And yet in many ways today's challenge is quite different from previous periods of urbanization. The most significant departure from historical patterns is the scale and complexity of the open-systems networks that now define urban economies and the flow of resources and money. We have seen the emergence of a single networked urban world in which every part of the globe is connected to the great cities of the world – a '"cyber space version of the old Hanseatic League". The network spreads from a handful of 'world cities' through a hierarchy of urban regions at tiers from sub-global to county. This is a sea-change in the nature of urbanisation, similar to the massive changes that accompanied industrialisation in the 19th century, and deindustrialisation in the 20th.

Urbanization is no longer a characteristic of developed countries: consider Argentina at 89% urban, Chile at 85%, Uruguay at 91% and all of Latin America and the Caribbean at over 75%. Although the challenges of urbanization vary with culture and geography, the similarities are the dominant theme. Urban infrastructure in the developing world is often an exact copy of what can be found in developed nations - in some cases designed by the same engineers.

The next few decades will witness an unprecedented investment in the built environment and especially in the urban infrastructure systems. Annual infrastructure investments of trillions of dollars are estimated, just to maintain basic services in cities worldwide [CERF 96]. If such investments are made without proper consideration for embodied impacts, and without attention to the long-term costs for maintenance and replacement, it is hard to imagine any real success in sustainable development. In fact, given the value of the existing built resource, and the increasing scale of the associated flows and impacts, sustainable development is in large part an exercise in guiding a conservative transformation of buildings and urban systems. [YANG & KOHLER 05]

If thinking about the long-term is the challenge, and urbanization is the threat, then ultimately everyone involved with designing the constructed environment, from the building scale to entire urban systems, may need to adopt new timing tools.

1.2 Questions

This thesis will explore the role of time in urban system design. Three questions in particular are addressed.

Firstly, how do concepts of time affect the manner in which society constructs urban systems? This question is explored in three parts: What do we mean when we talk about time, and how is the time concept changing? What is the relationship between concepts of time and the nature of constructed environments? And what analytical methods might help to integrate new – more sustainable - time concepts into urban design?

Secondly, how do extended time horizons and new time concepts affect our understanding of what is meant by sustainable urban systems? This question also has three parts: Do new time concepts affect our ability to design for efficient use of resources within urban regions? Do new time concepts affect our ability to assess risk and design secure urban regions that can fully recover from future shocks and surprises? How do new time concepts affect the structure of design teams, their scope, and the design and decision-making process?

Thirdly, what happens at each stage of the design process when new time concepts are introduced? This question is addressed through applied research in three parts: How do time horizons affect overarching conceptual frameworks that design teams use to organise their work? What changes occur in the composition of actors, and in the design and decision-making processes, as a result of extending time horizons? And finally, what new 'timing tools' might help urban designers cope with the complexity of extended time horizons and the unfamiliarity of new time concepts?

1.3 Terms

Interdisciplinary studies require a language for communicating across professional boundaries. In part this can be achieved simply by settling on a common glossary for key terms. However sometimes new terms must be developed and adopted to allow for changing paradigms. This thesis will require a bit of both.

Terms such as 'urban design', 'urban region' and 'urban system' are themselves evolving, and are used differently in the current literature. Consequently I will begin by clarifying these three important terms along with the concept of time scales. It is these terms that are central to the thesis questions. As the questions progress, it will be necessary to discuss how the meaning of these terms may need to evolve.

Urban design refers to the design of buildings, groups of buildings, space and landscape. Urban design is a process which can apply at the scale of villages, towns, cities, and regions. Its primary purpose is to create a desirable environment in which to live, work and play. [UK Planning Portal] Urban design is related to urban planning, but focuses more on the physical design of places and deals at a more fine-grained scale than urban planning. It combines elements of architecture, civic design and landscape architecture. The analysis typically includes spatial and physical aspects of the relationship between buildings, streets, land use, open space, natural features, circulation, and human activity.

Urban systems refer to networks within and between urban areas. In the context of this thesis, the focus is primarily on the intra-urban systems, which normally include transportation, water, energy, materials, environmental resources and communications [CIUS]. The term urban system is used rather loosely. Sometimes it can refer to all types of critical infrastructure, both natural and human-made, wherever they may be located. Urban systems may also encompass elements that are not design related, including for example systems intended for management and administration, social services, economic development, emergency response and disaster preparedness, decision support, innovation and education.

Urban system design is an approach to urban design that focuses on some or all of the urban systems. It requires a 'systems perspective', by which is meant a more holistic view of the dynamic interrelationships between all the elements involved. Urban system design addresses how urban designers can shape and adapt urban systems via spatial planning, urban design, new technology, institutional arrangements, financial structures and government policy.

Time scales refers to the manner in which time is limited, graduated and valued within the planning and design process. Time scales provide a common reference for connecting different events, and thus provide a language for understanding change, managing change, and responding to change. Time scales for urban system design are a subset of this language, and traditionally are used for ensuring adequate financing, durability and supply capacity for urban infrastructure.

Urban region refers to a contiguous territory containing one or more central places of habitation and business, and including the core of the town or city, the development around the edge, the surrounding rural fringe and the accessible hinterland. An urban region may centre on a single city, metropolis or mega-city, or it may encompass a polycentric collection of towns and cities that are closely associated in geography, culture and economy. The rural fringe would typically include the natural amenities and resources that are critical to the urban survival and quality of life, including water catchment, major parks, and market gardens.

These broad definitions tend to obscure some very important questions about how terms have been used historically, and also how they might be improved in use heretofore. For example, the appropriate definition for an 'urban region' is a controversial question that has been debated since the origins of town planning in the early 19th century. An urban region may reflect jurisdictional boundaries, watersheds, air sheds, economic dependencies, cultural and historical connections, population densities, topography and climate and a practical commuting distance for residents. The ideal method for characterising an urban region is the focus of such movements as bio-regionalism, watershed planning and eco-city design. The choice of definition herein reflects the thesis research and scope, and is not intended to be universally applicable.

Within the subject areas addressed by this thesis the greatest source of confusion appears to arise from the intersection between 'urban planning' and 'urban design'. For this reason it now necessary to briefly elaborate on the relationship. As mentioned above, planning and design disciplines have tended to differ in both scope and scale. Urban planning is a longer-term, goal-driven process that facilitates public decision-making by describing how land is used and how multiple needs can be reconciled. Urban design, in contrast, is traditionally more local in scale, more narrow in the range of professional input, focused on specific objectives and outputs, with more attention given to the aesthetics of form and to the dynamics between the functional elements.

When the design occurs at scale of an urban region, and includes long-term strategies for integrated and inter-related systems, the traditional divisions between planning and design tend to collapse. The macro scale means that the exercise may include all aspects of land use – and hence a planning focus is required. However the systems perspective requires that the designers work with a syntax of forms and relationships, treating the region in effect like a large room in which elements are carefully organised to achieve something that works effectively both as a living environment and as a technological system. [Kelbaugh 97] Moreover a systems perspective can lead to strategies for networked, holistic approaches that incorporate even the slowest-moving elements like transportation infrastructure and local culture. In other words, long-term design may address fundamental aspects of how people live and experience the world, and the designs must therefore be driven by community-based goals, similar to a comprehensive planning exercise.

So for a combination of reasons urban system design at the regional scale with long-term horizons becomes a mélange where design and planning may be part of a single process. Thus a cautious re-interpretation of these concepts becomes part of the larger context for research into sustainable urban systems. In the words of Taeke de Jong and Rosemann, writing in *Ways to Study and Research: Urban, Architectural and Technical Design*: "The ability to free oneself from old categories, to choose a new focus, is the hallmark of creative researchers and designers." [DE JONG 02]

1.4 Methods

A literature review was combined with workshops, design exercises, modeling, comparative analysis and visualizations. The literature review included the principle texts on the concept of time and timing tools, and an intensive study into the related subjects of sustainable community planning, the history of urban planning and design, urban futures, urban metabolism and life cycle assessment, emergency planning and disaster preparedness, scenario planning and forecasting, methods for decision-support and visualization, and the evolution of regional planning methods.

The applied research began by defining a generic framework intended for use in designing urban systems. This framework provided a means of structuring both the research and documentation.

An intensive 3-day interdisciplinary workshop produced hypothetical designs for urban regions, and helped me to explore key concepts and identify the principles of long-term integrated system design. The hypothetical design exercise lead to an empirical case study where the author directed expert groups, prepared reports, and executed a series of public events culminating in a long-term urban system design for an existing urban region: Greater Vancouver.

The Vancouver case study lasted 2 years, and provided an opportunity to closely observe the process of long-term design, and to document first-hand how changes to time scales and other systems boundaries, combined with a more interdisciplinary and integrated design process, may affect outcomes at each stage in the design framework. The scope of the field work also provided an opportunity to test in the real world a range of new concepts and timing tools. Such tests were introduced as nested experiments within the larger case study (Figure 1), and provided an opportunity to explore and compare methodologies. The case study also provided an opportunity to interact with a number of international teams engaged in similar work, and to compare and contrast results from urban regions on several continents.

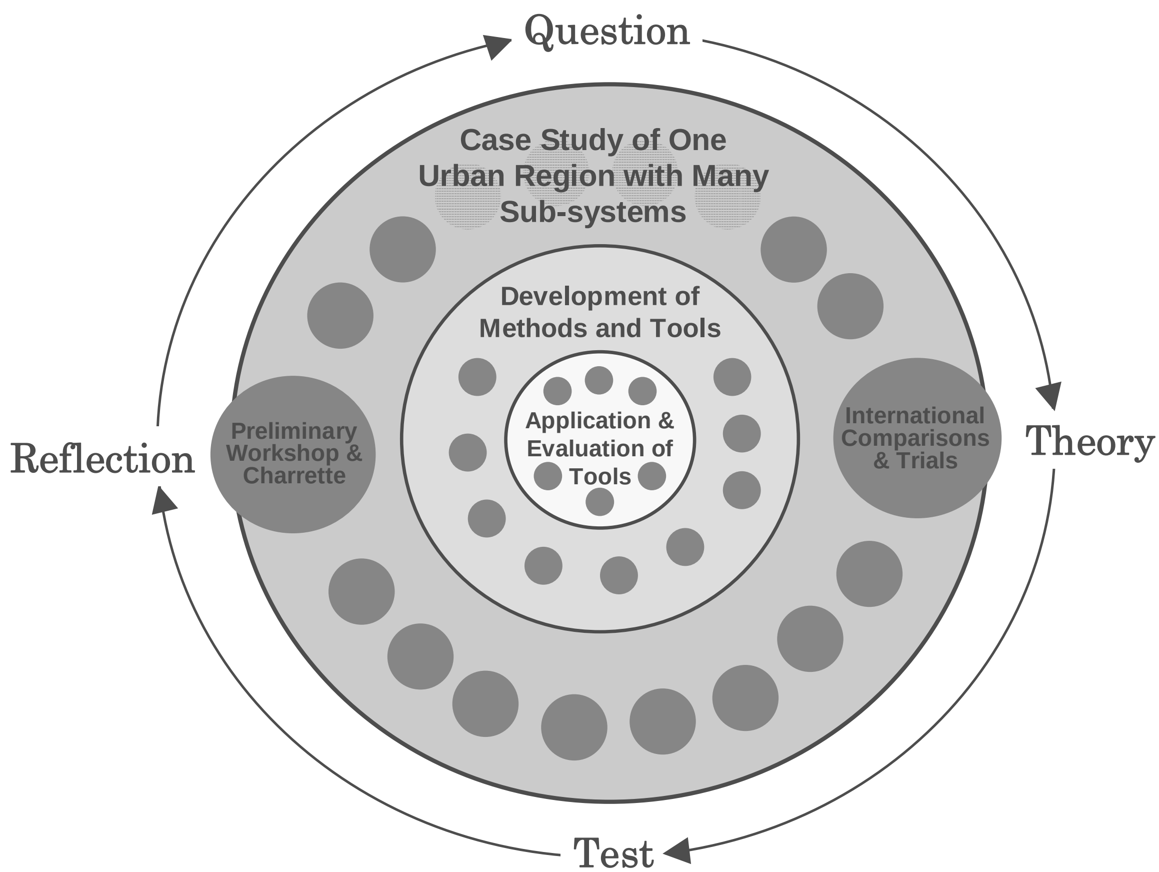


Figure 1 The research method follows the Learning Cycle, and is based upon a case study of one urban region - Greater Vancouver – with many discrete experiments for the urban sub-systems, and the new methods and tools for timing.

A detailed description of the field research, including the case study, is covered in a separate Chapter. The detailed description serves two functions. Firstly the research method constitutes a research result – a unique, field-tested template for operationalising long-term urban system design. Secondly it provides necessary background to the discussion on results that is presented in subsequent chapters.

The scope of the field research work required participation by interdisciplinary teams of researchers and advisors, who became involved in the applied research on urban system design, including workshops and charrettes. Their involvement provided a mechanism to assess the impacts of time scales on both process and product, and to achieve integrative, creative thinking on urban design methods. Integrative thinking may be essential when addressing questions that are interdisciplinary, complex and futuristic. The case study as a whole was an attempt to integrate micro and macro system design, and thus required input from a cross-section of design professionals, especially architecture, landscape architecture, planning, civil engineering, mechanical engineering, economics and resource management.

While all of the activities described in the primary case study were led by the author, in some cases specific reports and analytical work cited as part of the case study descriptions were produced in concert with research colleagues and assistants. In such cases co-researchers are referenced.

1.5 Structure

The thesis is organised into six parts, beginning with the introductory material. PART 2 and 3 address the first two research questions. In almost every case the sub-questions are allocated separate chapters. Part 4 describes the experimental research and Part 5 discusses the third research question. Part 6 is a reflection on what has been learned, and what new questions have been generated.

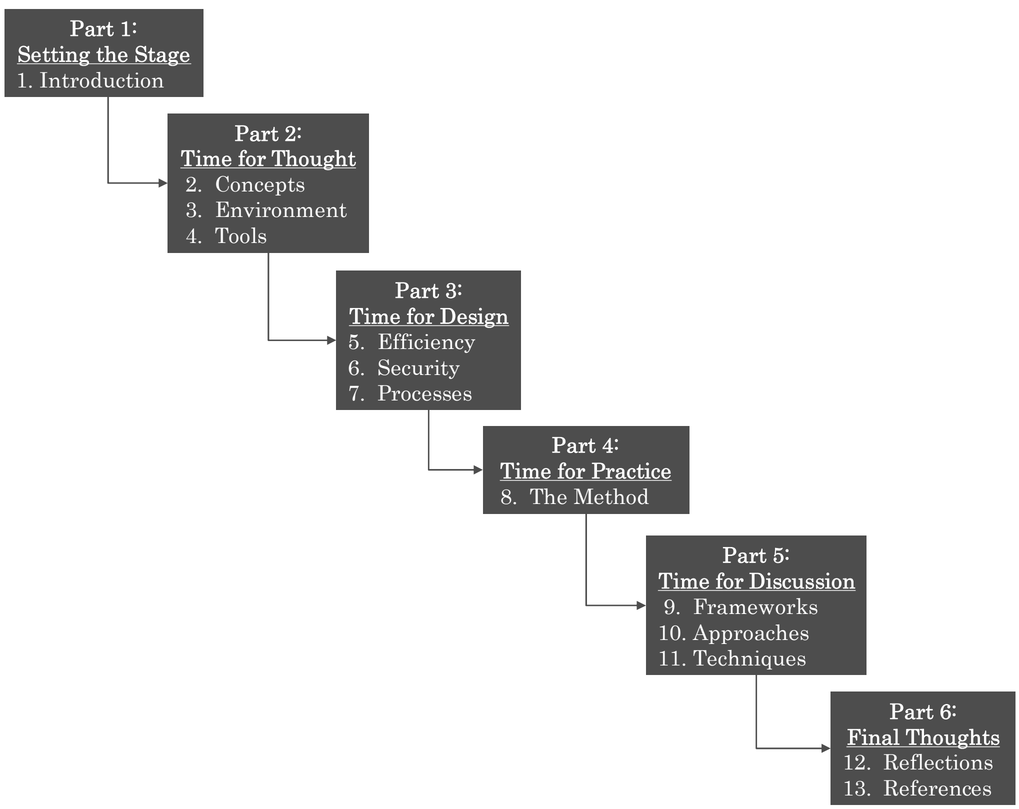


Figure 2 The thesis is organised into six parts that address the key research questions and into chapters that address the separate sub-questions

PART 1: PART II: TIME FOR THOUGHT

What scope for action in time is there for timely interaction?

Helga Nowotny 1988

Concepts at the level of synthesis of the concept 'time' are still outside the horizon of knowledge and experience.

Norbert Elias, "Time: an Essay" 1987

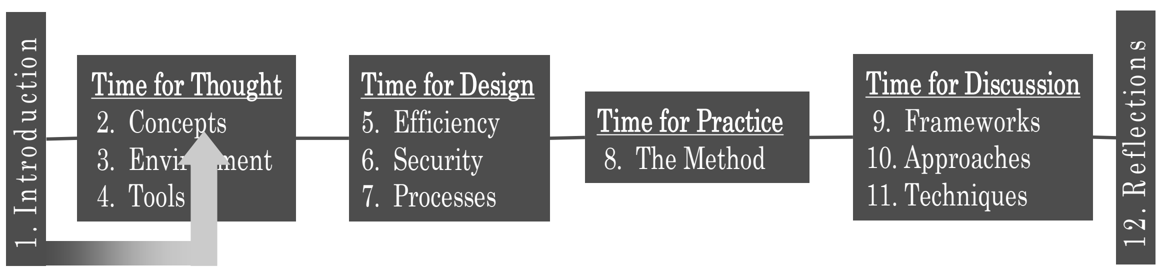
… a horizon is nothing, save the limit of our sight.

Bede Jarrett, Dominican priest, early 20th century

2 What is the Time Concept?

Human time refers to the notions and tools that are used by humanity to understand past, present and future, and to communicate time-dependant concepts. Human time is tightly bound to other value-based aspects of culture, such as self identity, sense of place and life purpose. Depending upon the cultural context, the term can have widely divergent meanings, both colloquial and professional.

The overlap between time concepts and cultural norms makes it difficult to examine the influence of time on urban design. Is it possible to influence the sustainability of plans and designs simply by identifying and adopting 'timing' tools more suitable for sustainable design? Is it our time sense, and our time preference, that influence decisions? Or is it our sense of time itself that adapts in order to accommodate changing technologies, economies and social norms? Or perhaps causality moves in both directions. Given the complexity of variables that shape cultural norms, no easy answers await such questions. This chapter will explore these many dimensions of the time concept, and search for alternative timing tools that may contribute to sustainable design.



2.1 What is Human Time?

To some extent human time is an extension of the natural faculties with which humans are endowed. From this perspective, time is a 'sense' intrinsic to the organism and mediated by our cognitive faculties. Concepts of time that are not intrinsic or instinctual are invented, and become part of the 'social construction of reality', in which each person's life becomes "an episode in the externally factitious stream of time". [BERGER 66]. The division between what part of our time sense belongs to nature, and what part 'nurture,' appears to have been a source of confusion and debate through history.

Philosophical works by Kant and Hegel place a special emphasis on the time concept, and assume that discovering our inherent time sense is part of self-knowledge. Conversely, many sociological studies argue that almost all of the time concepts discussed by philosophy and science are simply an expression of cultural norms, and can be shown to vary from one era or culture to the next. [THOMAS 96] [ADAM 90] Scientific time has many variants, and is a variable used by all modern scientific disciplines, and an intrinsic element of the scientific method. Understanding the evolution of current timing concepts, and how these concepts reflect aspects of changes in genetics and culture, provides important context for an exploration on how time might be used differently as part of sustainable urban system design.

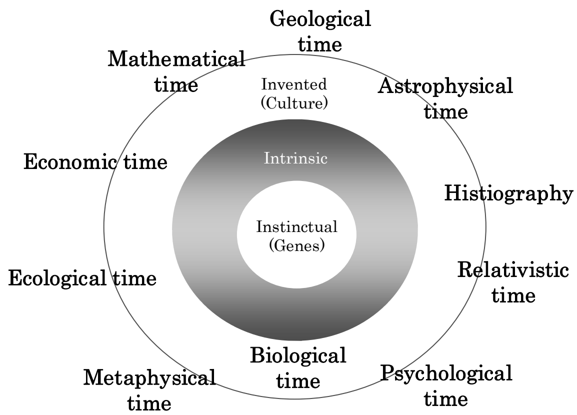


Figure 3 Human time is embedded in our bodies, in ourinstinctual, intrinsic to humanity society, and part, part of culture, and is embedded in all science

2.1.1 Biological time

Time for human beings, like all life forms, probably originates with the sense of rhythm. Rhythm is a concept that embodies the time-dependent attributes of repetition and simultaneity. Both plants and animals exhibit behaviours that provide conclusive evidence of an internal or endogenous clock that oscillates at varying frequencies. This body clock explains the circadian, circannual and tidal rhythms that are used by species for mating, feeding, migrating, and hibernating. Only cellular organisms that live and die in periods of hours fail to exhibit evidence of body clocks. [WHITROW 80]

For early humans, the body clock must have been the foundation for timing concepts and language. It may be this innate sense of rhythm that allows members of the tribe to function with precision as collective units, whether it is to harvest or hunt, to dance or make love. Or perhaps rhythm is intrinsic because it has served human evolution in other ways. Notably it is rhythm that provides humanity with a foundation for the construction of speech, since all spoken language depends upon cadence.

Regardless of function, rhythm would seem to be one of the few ingrained aspects of the human mind. Even a newborn responds to rocking and music, and in so doing the newborn uses repetition and simultaneity as a means of orientation to the external world.

Many types of body clock 'oscillations' have been examined for timing functions, for example menstrual cycles, or the frequency of alpha waves that characterise the brain at rest. It would appear that the body is a clock that is programmed to the natural environment in which it must survive. The clock never stops – for example a person can use the clock to decide to wake at a given time. The basis for such internal timing is not well understood. Body clicking and synchronization may be calibrated by radiation, gravity, temperature or something unknown. Whatever the mechanism, it is this internal and innate sense of time that allows all humans to keep track of time as a flow.

To use the body clock as a tool for social organisation requires either instinctual responses or a learned timing concept. In most species group activities are largely governed by instinct. For example, hoarding behaviour, or mating or migration may be triggered by shortening daylight hours. In humans, menstruation is an example of a such timing, but the amount of instinctual programming is very minor relative to other species. Basic concepts of time need to be communicated to each member in order for any human group to function as a collective. Communication of timing is bound up in symbols and cultural rituals which are used to interpret or codify the incessant flow of events. The harvesting and putting away of food, for example, has become a prescribed activity, directed or 'timed' by religious leaders since time immemorial.

From this perspective, some degree of 'timing' language is a characteristic of the human species, and thus cannot easily be defined exclusively as an attribute of culture. It is intrinsic to the species, as our genetics and culture have co-evolved. Thus timing is both a learned concept, and an essential and universal feature of all human societies.

It is likely that the emergence of time sense in the child mirrors the evolution of time sense in the human species. For primitive humans timing tools must have first evolved to discriminate between commencing, continuing and completing actions. These patterns are learned behaviours - mental constructs - which lead to an internal sensation of a desired future. This sense of 'future outcomes' allowed early humans to better adapt to changing conditions, a phenomenon that can be traced in prehistoric hominoids. Development of the prefrontal lobes of the brain of Homo Sapiens, for example, is associated with the ability of early humans to adjust to future events – making tools to make tools for example. Presumably the forward-direction tools are applied in reverse, and become the basis for coherent memory.

Some of the first research specifically on the psychology of time was initiated by Einstein who asked Jean Piaget, a leading childhood development expert, how a sense of time develops in children. Einstein's query was provoked by his thinking on velocity and relativity. Since time and movement are inseparable when examined from the theory of relativity, Einstein wondered if the two interwoven concepts were grasped at a similar stage of childhood development.

Subsequent work on the psychology of time revealed that a child's emerging sense of time has much more to do with language than with space perception. [PIAGET 54] [FRAISSE 63] In simple terms, the newborn knows only the 'eternal now'. A more refined sense of time may require a change in the now – a denial or delay in the satisfaction of bodily needs such as the breast, warmth, sleep, and a lack of pain. From this perspective, it is in the denial of basic needs - and the experience of suffering in the now - that the child first experiences a sense of separation or self. Time is thus a part of the process of acquiring self-consciousness. With the denial of pleasure, or the imposition of pain, the child experiences muscular sensations and reactions. "A hungry baby reaches for food." [GAYAU 1890] Every need implies the possibility of satisfaction, and the aggregate of these possibilities leads to a concept of 'grasping' the future. The psychological origin of time is therefore to be found in the conscious realization of the distinction between desire and satisfaction, which in turn lead to abstractions such as a uniform temporal sequence and a definite causal process.

By 18 months of age an infant's understanding of time begins with the concept of 'not now', or duration. At approximately two years of age the infant can understand 'soon', a quantification of duration. At about 3 years the terms 'tomorrow' and 'yesterday' are generally understood, giving the child both a more precise time, and a repetitive pattern of events, or temporal succession. At the age of 4 or 5, a child can understand and describe sequence, as events are ordered and progress in their 'local' time. By the age of 6 or 7, a child may begin to recognise that two sets of observed events that begin and end simultaneously are actually of the same length, and this creates the potential for abstract concepts of a 'common' or shared time. [LEVIN 89] It also allows for the sense of time passing at a pace that is normal, too slow or too fast – the synchronicity of time.

It is probably at this stage that the human 'biological' time sense and survival needs have matured. Moving beyond the concept of shared time, at the age of 7 or 8, is a move away from direct experience, into abstractions that depend upon concerted, repetitive training by family and society.

The culturally defined norms for timing are constrained by the capacity of the human brain to sense time and assess relative concepts such as duration and synchronicity. Some of the experimental research on cognitive aspects of time has attempted to understand the relationship between information density, time sense and synchronicity. In very general terms, the greater the quantity of new information associated with an event or sequence of events – i.e. the information density - the greater the individual's sense of duration. This phenomenon explains much about the experience of time, although much dispute exists over the actual role of information. Routine activities involve little effort by the individual in information storage, and thus time seems to travel quickly. Where much information processing is required, time can drag. Information density may also explain the 'order of sequence' error, wherein two events of identical duration will consistently be judged as differing in length. Perhaps because the mind remembers the more recent event in greater detail (i.e. with more apparent information density) it will always be perceived as of longer duration. [FLAHERTY 99]

Common sense and personal experience can help to corroborate these types of relationships. For example, a person with little knowledge of antiquity might perceive the Assyrian era to be far removed from the present – a barely perceptible blip in the misty reaches of human history. If any thought is given to the blip, it is likely to appear relatively short in duration when compared with the span of the modern era. However a scholar of antiquity will see Assyrian times as much closer to the present – with many direct connections such as the origins of writing, religion, irrigation, warfare and so on. The scholar will also see the Assyrian era as a rich story with many chapters, - a period in history lasting from 1960 BCE to 612 BCE, a period much longer than modern times.

Such perceptions raise speculative questions that have relevance to the thesis questions. If increasing information density extends perceived duration of events and makes the events appear more recent, is it possible to use information per se as a timing tool? In other words, by conveying more information on future events – through narratives or scenarios or simulations – to designers and decision-makers, is it possible to slow down the apparent pace of change and to bring the high-density future events closer to the present? If so, information transfer may serve to collapse horizons, and automatically transform long-term thinking into a short-term norm.

2.1.2 Cultural Time

The time concept serves to orient individuals within their lives and within the larger community. This orientation is a characteristic of culture, thus culture determines the texture of time – its pace, direction, pattern and purpose. Within the larger cultural context, the perception of time varies with the scale of the lifetime in question. On average, an individual lifetime may range from 35 to 95 years. However as a part of the larger community, the lifetime extends to thousands of year. Freeman Dyson describes the complete extent of time scales for humans:

> *"The destiny of our species is shaped by the imperatives of survival on six different time scales. To survive means to compete successfully on all six time scales. But the unit of survival is different on all six time scales.*
>
> *On a time scale of years, the unit is the individual.*
> *On a time scale of decades, the unit is the family.*
> *On a time scale of centuries, the unit is the tribe or the nation.*
> *On a time scale of millennia, the unit is the culture.*
> *On a time scale of tens of millennia, the unit is the species.*
> *On a time scale of eons, the unit is the whole web of life on our planet.*
>
> *Every human being is the product of adaptation to the demands of all six time scales. This is why conflicting loyalties are deep in our nature. In order to survive, we have needed to be loyal to ourselves, to our families, to our tribes, to our cultures, to our species and to our planet. If our psychological impulses are complicated, it is because they were shaped by complicated and conflicting demands." [DYSON 1979]*

Dyson's time scales are nested, and thus can be visualised as rings of time superimposed upon a logarithmic time scale. (Figure 4)

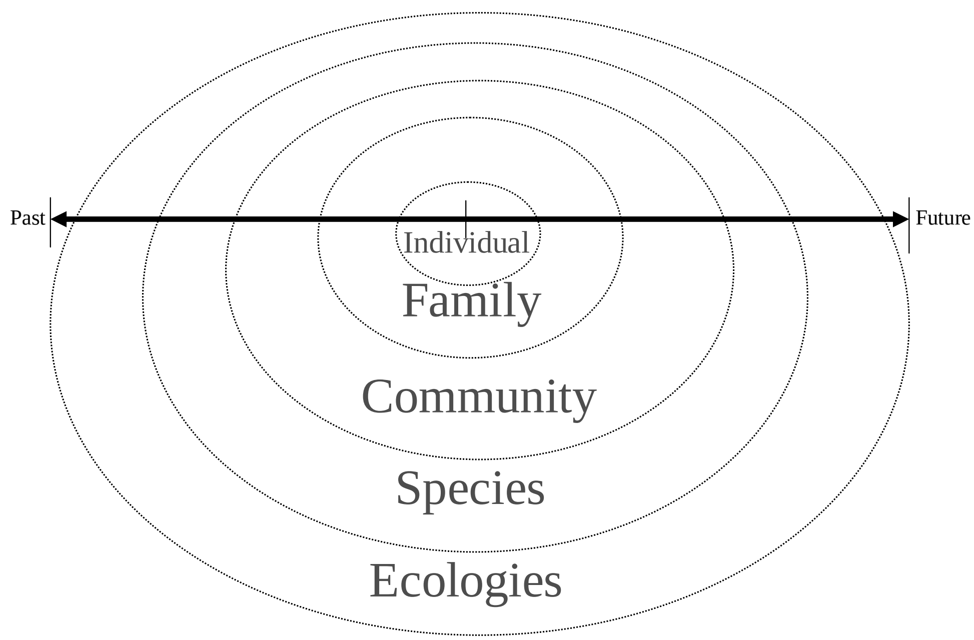


Figure 4 Six rings of time of importance to all humans, [Based upon a description of competing time scales in DYSON 79].

Depending upon the issue in question, the time scale varies. Stewart Brand provides a more graduated set of possible scales for civilization, ranging from the fast pace of changing fashions to the slow cycles of nature.

[BRAND 99] Again, these can be visualised as nested time rings. (Figure 5) Brand points out how teenagers will perceive time at the short-term scale of changing fashion, and then as they enter into commerce (earning a living) the scale extends. Time rings suggest that as the child grows into an adult, loyalty moves outwards to the longer-lasting elements identity - family, community, society and the ultimately the natural environment. The time rings also suggests a connection between longer time scales and sustainable decision-making. Brand argues "Rigorous long-view thinking makes responsibility taking inevitable because it responds to the slower, deeper feedback loops of the whole society and the natural world." [BRAND 99]

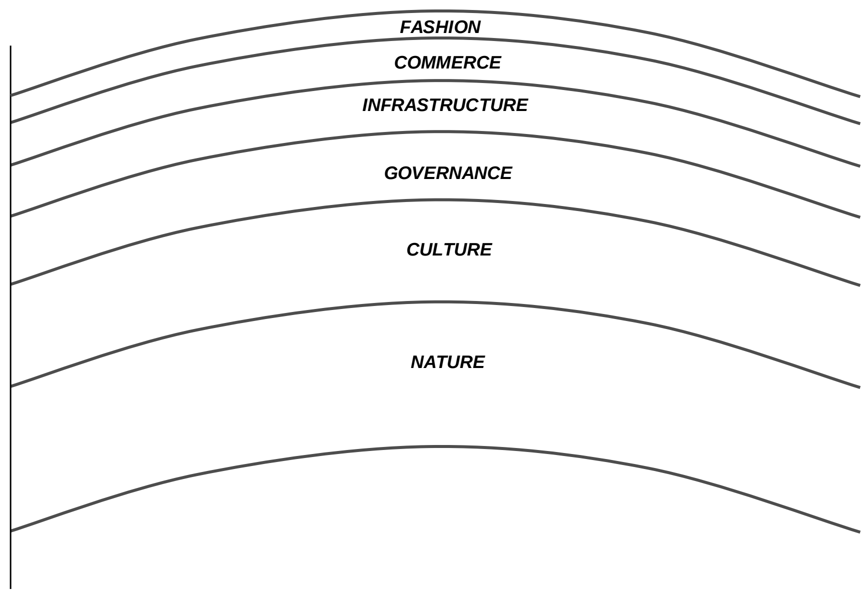


Figure 5 Time rings of civilization: "The fast layers innovate; the slow layers stabilize. The whole combines learning with continuity." [from BRAND 99, redrawn by author]

Perceiving time rings across all scales may be a critical aspect of social science research, and especially research into urban civilization. Fernand Braudel's basic premise, shared by the Annales school, is the importance of considering forces that shape the future across all time scales (or rings). In reflecting upon his own classic work *The Mediterranean*, Braudel observed that "my book is organised along several different temporal scales, moving form the unchanging to the fleeting occurrence. For me, even today, these are the lines that delimit and give form to every historical landscape." (BRAUDEL 72) He promoted consideration of longer time scales by all social sciences: "Should history by its very nature be called upon to pay special attention to the span often and to all of the movements of which it may be made up, the longue durée appears to us, within this array, as the most useful line to take toward a way of thinking and observing common to all the social sciences." [BRAUDEL 81]

The Function of Timing

The evolution of modern man required not just language and social structures, but a way to keep track of time for many social and cultural purposes. Body clocks cannot inform an individual when to rendezvous for a fishing expedition, to plant crops, to arrange a marriage, to meet for worship and ceremony or to gather for trading and celebration. Thus timing became a form of language, and like language, serves the needs of community.

All culturally derived timing is based on the use of standardised reference sequences. In essence, recurring natural patterns like the moon cycles and the sun rotations are used as a benchmark, against which other sequences can be related and indirectly compared. Time thus refers to the relating together of two or more continuously moving sequences of events by means of a common reference scale. Norbert Elias examines how society often confuses the symbol for the message, and claims this is the reason for much of the confusion around the question of what is time. From his perspective, there is no time for humans, only timing tools that serve to synchronize and orient individuals within a collective. [ELIAS 87] Or to re-phrase the point, clocks and calendars are not measurements of time; rather they are tools for timing.

Always the priests were the first in any society to perform timing. "Religion originally stemmed from human consciousness of the temporal process" [BRANDON 1959 in WHITROW 80]. Through a period of more than one hundred thousand years of trial and error the priests created concepts and methods for coordinating social and cultural activity. Even after the invention of the pendulum clock in 1650 by Huygens, its first use was primarily to assist religious orders in setting times for worship, prayer and the sacred events that have structured society since its origins.

As religious institutions survived for longer periods, so too could precise calendars and a collective memory of the sequence and duration of events. The Babylonian calendar – a major innovation in timing – became possible only as a consequence of the stability and long-term survival of the Nabonassaros dynasty. Relatively recently it became possible for natural scientists like Ptolemy to use these ancient calendars, and their records of astrophysical events, to develop new hypotheses about the physical world. In essence, scientific timing arose from institutional timing which was a function of religious orders operating within long-lasting dynasties. In the long-term, the innovations in timing lead to an evolution in language. The language developed for precise timing is at the origin of all modern time, and much of modern mathematics and science. [GOUDSBLOM 01]

As a communications tool timing has two broad functions: synchronization and orientation. Synchronization allows people to coordinate their independent action, with the potential for beneficial economics of scale and other synergies. Most notably, farmers at the beginning of the Neolithic age had to master timing to maintain the efficient production of the crops upon which their societies – and the first cities - depended. Orientation allows people to map their location in time, and in so doing, develop a stronger and more distinct sense of self and community. Through synchronization and orientation, timing allows groups of humans to live together more effectively and more profitably. In such ways innovations in timing tools have conferred advantage to human societies.

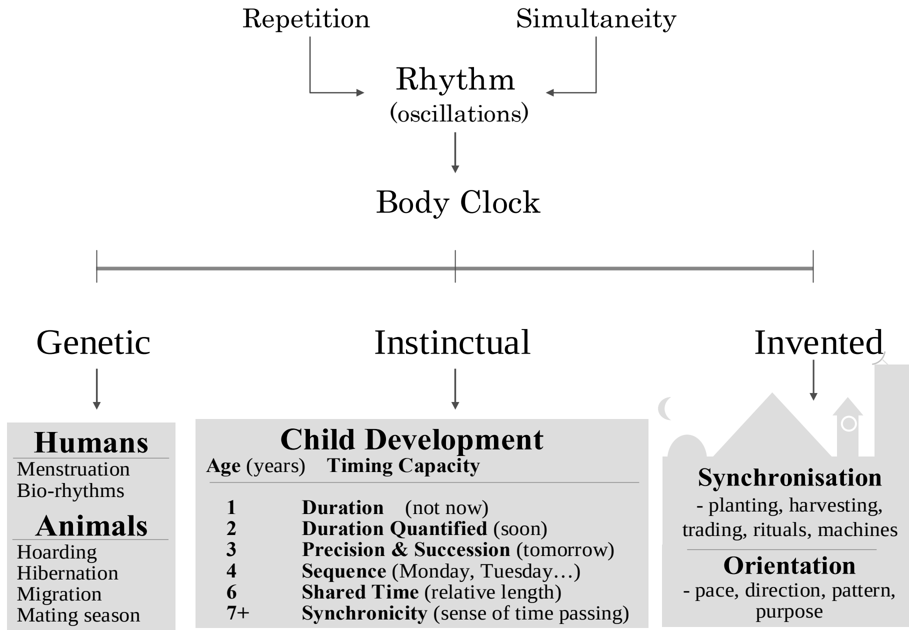


Figure 6 The body clock underlies three categories of timing: genetic responses, instinctual timing and invented timing.

The specific tools used in language for synchronizing and orienting people are difficult abstractions. In fact questions about time can be used to score a child's intellectual capability for abstraction. [WHITROW 80] At puberty only about 50% of children are capable of grasping the conventions used to sequence and compare different series of events. It requires ability for abstraction in order to truly understand concepts like daylight savings, date lines, leap years and historical periods. These conventions are based on logic. They do not involve any fundamental loss or gain in time; rather they are conveniences that simplify communications when attempting to coordinate activities or orient the individual within a larger context. It is precisely these conventions, Elias argues, that once learned take on a separate reality seemingly independent of the culture that created them, and thus individuals ponder the concept of time when in fact it is nothing more than a set of language conventions. [ELIAS 87]

Languages themselves have struggled with the methods for conveying time in events: the future, past, past perfect, future perfect. Even today the large majority of languages have no specific grammar for distinguishing even simple past from simple future. As a conceptual tool, "The evolution of time is revealed by the increasing importance of tense in the development of language." [WHITROW 80]

The evolution of time concepts may have accelerated in recent history. The industrialisation of society in modern time was accompanied by new time concepts that contrasted sharply with the earlier mythic world view of land-based cultures. Mythic time is characterised as cyclical and religious; modern time as linear and secular. However the relationship between these time concepts is not simple, nor is it necessary that all of humanity is fated to progress from mythical time concepts to a universal modern time concept. [VAN SCHENDEL 01] If timing is primarily a communications tool, the functional aspects of these different world views needs to be explored. Different timing tools from different cultures represent a resource that can be explored for concepts that may assist urban design.

Mythic Time

Land based cultures are driven by natural cycles – the growing seasons, the tides, the migration of animals and so on. In such cultures the most important function of timing is to synchronize human activity with eternal patterns of nature. Thus mythical time is rooted firmly in the basic ingredients of rhythm: repetition and simultaneity.

From a psychological perspective it may be difficult for modern humans to fully grasp mythical time since the rhythm is not just a metaphor. In mythical terms, all objects and events are facsimiles of previous objects or events, - a repetition of the ideal prototype. For this reason the life of archaic humans was characterized by the repetition of archetypal acts and the unceasing rehearsal of the same primordial myths, each a piece of an eternal moment that resonates with all other such moments. Everyone existed in an eternal or repeating present, and all cultural rituals served to reinforce the recreation of essentially the same series of events.

Even for the great classical civilizations, the principal transitions in nature may have been sudden, but were always seen as part of a cycle with a definite rhythm. For the Egyptians, Greeks, Hindus or Mayas, history was contemporary history, combined with the eternal repetition of the cosmic pattern. [BENEVOLO 80] The mummies and pyramids were designed for a static world with a definite future. Like the other early civilisations, the Egyptians and Greeks had no sense of their time as an era, which might ultimately include civilizations outside of their own. Their historical records are contemporary, but without much sense of distance in time. In ancient Egypt one pharaoh would claim historic victories of another two hundred years previous. The pharaoh's job was to maintain eternal order, not author or suffer unique events. The design canon for statue dimensions was rigid for 2,200 years. [BRAND 99)

Another characteristic of mythical time is that change was not conceived as a continuous process spread out in time, but as "discontinuous and abrupt". [WHITROW 80] History was composed of largely disconnected narratives – a dynasty, a major event, an age – each complete unto itself, rather than a continuous thread. (Figure 7) Time was also uneven in quality. Holy days and lucky days created 'magical' time, and the quality of this magical future was influenced by arbitrary forces.

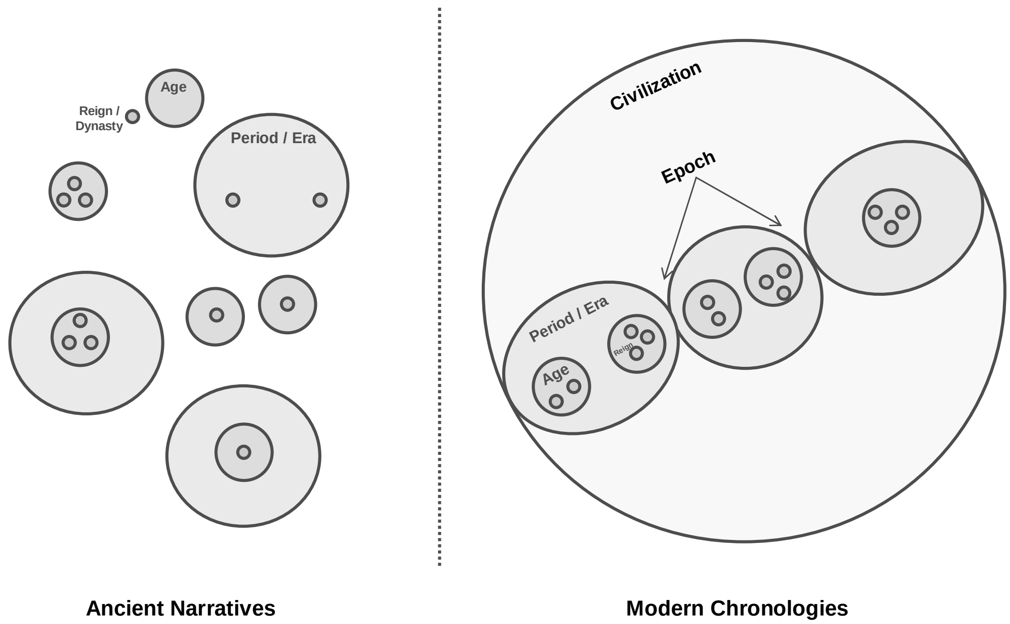


Figure 7 The texture of history (historiography) has changed from relatively disconnected narratives to a chronological sequence

Mythical time exists for surviving primitive tribes today. Anthropological studies reveal that such people lack a sharp distinction between present and future. Lives are not dominated by timing conventions, and language has no words for talking about time. Time is simply the eternal repetition of the cosmic pattern; a pattern that is to all extents and purposes static. The pattern is what directs and focuses the sense of time, and not the succession of years that have past, or their order and duration. The individual is "usually less sharply distinguished in his own consciousness as a unique person from the chain of generation that happens in highly differentiated societies at a later stage." [ELIAS 87]

The cycles of mythical time divide into a definite rhythm. If we imagine these divisions as bars in a musical score, then the base rhythm section would mark the times for planting and harvesting, hunting and fishing, and the individual and family rites of passage for birth, puberty, marriage, and death. Against this base rhythm a melody of magic gives the intervening times their special significance as defined by Saint's Days, almanacs, horoscopes, and fortunes. As the musical score plays round and round, the only precise timing required by land-based society is to determine when to plant, harvest or migrate. These decisions are made by the shamans or high priests. In land-based cultures, lunar phases provided the most obvious and convenient natural reference for communicating the passage of time. The moon is a sundial in the sky. Lunar phases coincide with menstrual cycles and thus are a fundament unit for 'human' periodicity. The term 'moon' is derived from same etymological root as 'measure'; the moon god is the god of time and measurement. Some of the first evidence of numeracy and measurement are the scored horns or crescent moons used by Neanderthals to record the 13 moon cycles in a year. [GOOCH 89]

Heavenly bodies thus provided a currency for exchanging information on events occurring in people's lives. As this 'universal time', is absorbed in thought and language, it reinforces the concept of a universal world order modeled on heavenly bodies, something that underlies ancient and modern thought. Thus from rhythm and periodicity come speech, and from heavenly cycles come a universal scale for the measurement of time and the concept of a world order.

Modern Time

Modernism, in broad terms, is a term that describes, prima facie, a period in which time itself becomes an element of history. Modernity is the awareness that time is passing at a dizzy pace, and that things are quickly changing in time, usually for the better. The modern world view is especially well characterised by Henry Adams, writing in 1914 in "The Education of Henry Adams", he looks back and forward in time, and eloquently describes his 'modernist' vision of what life will be like in the year 2000:

> *For this new creation, born since 1900, a historian asked no longer to be teacher or even friend; he asked only to be a pupil, and promised to be docile, for once, even though trodden under foot; for he could see that the new American - the child of incalculable coal-power, chemical power, electric power, and radiating energy, as well as of new forces yet undetermined-must be a sort of God compared with any former creation of nature. At the rate of progress since 1800, every American who lived into the year 2000 would know how to control unlimited power. He would think in complexities unimaginable to an earlier mind. He would deal with problems altogether beyond the range of earlier society. To him the nineteenth century would stand on the same plane with the fourth--equally childlike--and he*

would only wonder how both of them, knowing so little, and so weak in force, should have done so much.

ADAMS 1914 Chapter XXXIV "The Law of Acceleration"

The modern time concept is connected to the economic and political transformations that began in the early Middle Ages, as market squares, initially organised by monasteries, began to enforce fair trade and to print money, thereby generating revenue for the land-owning aristocracy. [MUMFORD 38] Eventually market towns became sought after by rulers as a source of new wealth, and the towns themselves were in a position to negotiate freedom from feudal bondage, with 'free' men selling wages and operating craft businesses. Although this process began in the 10th century, mythical time prevailed up to the 17th century throughout most of the world. The rise of the mercantile class changed this first only as a potential – since power was concentrated in ownership of land, and land was associated with the unchanging cycle of the soil. But once money starts to circulate widely – in the trading houses of Amsterdam and later London – time is treated as a scarce commodity. The efficient use of time becomes a strategy for increasing wealth and power. Time is money.

In the 1870s the merging of natural and machine times in daily work routines is taken to an extreme with Taylorism, and later becomes institutionalised in the new factories as Fordism redefines the role of people as workers and consumers in the new society. The industrial capitalist logic of production makes time an increasingly scarce commodity. Time is speeded up as everyone searches to do more in a given period, or find more time to do more. The economic incentives produce societies that are time aware, time efficient, and time dependant. [NOWOTNY 94]

In modern time emphasis is less on repetition and simultaneity, and more on succession. A modern city-dweller will likely know the era in which they live, the year, month, day, hour and minute – more or less – all of their waking adult life. And they can communicate complex timing information accurately to people in all modern cultures, worldwide. But as precision increases the sense of magic and cycles is diminished. Modern time tends to be relatively homogeneous and linear. It is as if time is another commodity of the industrial age, extruded or manufactured to standard specifications and mass-produced into identical boxes like the products of a running shoe factory.

The linear, progressive and all-pervasive time consciousness thus becomes a defining attribute of the modern era, and leads to what is sometimes referred to as 'modernity's time consciousness', where a horizon of possibility keeps perpetually open the promise of a future different from the past, the promise of a new beginning. [HAMBERMAS 87] [KOMPRIDIS 01] This open, expectant stand to the future exposes the meaning of history to ongoing reinterpretation, and the new and old continuously collide in the present. Everywhere society is forced to wrestle with the issue of continuity and a heightened sense of uncertainty.

Standardised Time

The progression from land-based societies to modern urban lifestyles would not have been possible for societies measuring time in moons. The accurate pendulum clocks of the mid 17th century provided not only a means for fine control of timing, but also a metaphor for the emerging scientific perspective on time, in which time becomes a continuously clicking homogeneous stream. The industrial revolution and the machine age that emerges in the 19th century brings for the first time a standardised time for humanity. This was one of the most defining elements of the industrial era, and is inseparable from the urbanization process. The clock is the ultimate symbol of the modern era: the eternal cycles are replaced by metronomes that synchronize all human activity to a "machine society that never sleeps". [MUMFORD 38]

The standardisation of time between the cities began with infrastructure design and management: the railway systems in Britain and the US required common time zones for scheduling arrivals and departures. In 1884, the International Meridian Conference established a system of time zones and a prime meridian. Their decisions followed conventions already established by seafarers, and more significantly by the railway associations in England and the USA.

The first long-distance telephones were installed in the stock exchanges to assist traders in coordinating the markets. Further infrastructure systems for information and communications technology (ICT) - telegraph, telephone and radio - helped to make universal time pervasive in human consciousness. From transport, to trade and then to social lives the effect of urbanization was to create an all-encompassing, worldwide simultaneity – a perception of events and processes occurring at the same time despite vast distances in geography. The present was everywhere shared.

Stephen Graham describes the emergence of a modern world defined by infrastructure: "From the initial, general, picture of heterogeneous, partial networks, of poorly inter-connected 'islands' of infrastructure and of extreme uneven development in the infrastructural capacities of different urban spaces emerged, over the period 1850-1960, single, integrated and standardised road, water, waste, energy and communications grids covering municipalities, cities, regions and even nations." Graham goes on to argue that "infrastructure development and urban planning – were constructed as key elements of the broader project of modernity….The new technologies surrounding networked urban infrastructure were thus seen to be mechanisms to control time through instigating waves of societal progress." [GRAHAM 01]

The spread of networked infrastructure and universal time has been a remarkably rapid and relatively recent phenomenon. Functionally unproblematic calendars have existed for only about 60 years. "It took several thousand years for people to learn how to produce calendars in which the human representation of time in the symbolic form of recurring time units needed for the regulation of social events, and the natural sequences on which the symbolic representation was modelled, did not sooner or later fallout of step." [ELIAS 92]

Modern time concepts continue to regulate behaviour and provide orientation for the individual within the ceaseless flux. However in a machine society, the synchronization occurs moment to moment, allowing highly complex systems, with many interdependencies. It is now normal to calibrate individual time to the second, and machine time can be as precise as millionths of a second. And we use precision at much larger scales to orient ourselves within history. Our lives are now seen as events, within a chronology that begins with the universe itself, and ends with the individual in the present.

Time preference is the term given for preferring the sooner to the later. It is closely related to time orientation and to the loyalties in time described by Dyson and Brand. Modernism has placed an emphasis on individual lives – as an outgrowth of many factors: mobile populations, small families, longer lifetimes, consumerism, and secular world views. As the individual becomes more central to decision-making, choices increase. The difficulty with individual choice is the scarcity of time, - each of us has only so much time, and so many choices, and thus time is like a scarce product that must be economised. The scarcity of time requires a value be given to satisfying desires in the more immediate as opposed to the more distant future. Time preferences vary depending upon habit, self control, length and certainty of life, regard for offspring and posterity, and even fashion. These factors interact, and influence the ratio between present and future goods in the community. Natural cycles and a localised community are lost in the highly scheduled and fragmented activity of urban work and travel.

The impact of changing time concept on community values is a much discussed phenomenon. Observing the impact of industrialization and urbanization, Engels described the results in London, the modern world's first conurbation:

> The more that Londoners are packed into a tiny space the more repulsive and disgraceful become the brutal indifference with which they ignore their neighbours and selfish concentrate upon their private affairs. We know well enough that this isolation of the individual – this narrow minded egotism – is everywhere the fundamental principle of modern society. But nowhere is this selfish egotism so blatantly evil as in the frantic bustle of the great city. The disintegration of society into individuals each guided by this private principle and each pursing his own

> aims has been pushed to its furthest limits in London. Here indeed human society has been split into its component atoms.
>
> Engels 1858
> "The Condition of the Working Class in England"

The 'atomisation of society' described first by Engels is a process which continues today to varying degrees, especially throughout the rapidly industrialising and urbanizing nations. As Norbert Elias noted in his study of the civilising process, the pace at which people live is a function of the amount of social connections in which they are involved. [ELLIAS 94] In the mid 19th century, 'political scientists' viewed the social disorientation within cities as a positive influence because of its potential for developing within workers a revolutionary class consciousness. The misery of city life was a necessary price to pay for emancipation from past authoritarian society and the "idiocy of rural life". [CHORNEY 90] The misery of urban life stimulated others to put forward more pragmatic solutions, which led to the birth of utopian planning and the modern town planning professions. Ebenezer Howard's vision of Garden Cities, for example, was based upon a society of voluntary cooperation among men and women, working and living in small self-governing commonwealths. [HALL 02]

Each culture adopts different degrees of accommodation to the imposition of universal time by a global economy. In writing about global and local time in Asia, Van Schendel and others describe the many co-existing methods for timing, and how the cultures continue to rework and appropriate meanings around the ordering of time at different social levels: political, religious, economic, and academic. In a widely used almanac in Bangladesh, for example, no less than fourteen different calendrical systems are mentioned. [VAN SCHENDEL 01] Calendars, and their embodied time scales and periods, are grand narratives that convey messages about the nature of the world, and the role of groups within society. The ideological character of timing tools becomes clearer in locations where many different approaches are competing; in the developed west, the competition in timing tools is much less visible, and so too the ideological foundations to timing.

Post-Modern Time

If modernism is defined as the era when time knows itself, then post-modernism, the period following the second world war, is an era where time is not only a defining element of history, but also part of a problem. The ideology of progress, so closely associated with modernism, is eroded by changes to economic conditions and by increasing external costs. By the 1980s, real wages are no longer rising in many developed nations. And the rich and poor alike are vulnerable to a growing list of global environmental hazards.

And so the time concept in the modern urban centres begins again to transform, moving from a wonderful defining feature of contemporary society, to a troublesome and disrupting force. Adrian Atkinson describes post-modernism as an "acknowledgement and celebration of incoherence that has the effect of undermining the enlightenment project." It is a grand narrative without a narrative, a change in the 'structure of feeling' more than the paradigm, a new world in which there is no longer any widespread belief that any given question only has one true answer. Atkinson claims that all of this "has the effect of undermining any moral project and in practice, with the rise of the aesthetic – a figural culture over the discursive – aesthetics becomes the chief mode of social judgement; the continuity of values and beliefs is broken and these become subordinated to style and fashion." [ATKINSON 91].

This structure of experience Atkinson describes is especially defined by urban life and urban space: "post-modernity seems to involve a speeding up, an intensification, a spreading out of the urban experience; the life of fragmented identities, instantaneous connections, and constant movement is becoming the norm everywhere. Post modernity may involve a new spatial order, but that order is a child of the city and not the state." [MAGNUSSAN 88]

In *The Condition of Postmodernity: An Enquiry into the Origins of Cultural Change* David Harvey develops a more extreme analysis. He argues that postmodernism extols the ephemeral, the discontinuous: it "swims, even wallows, in the fragmentary and the chaotic currents of changes as if that is all there is." As a result, it "abandons all sense of historical continuity and memory, while simultaneously developing an incredible ability to plunder history and absorb whatever it finds there as some aspect of the present." He attributes the loss of time sense to the hyper-flexible methods of producing wealth which compress both space and time and which lead firstly to over-accumulation and latterly to an economy that must endlessly create new wants and needs. [HARVEY 89] Based upon his analysis, the application of long-term timing tools to urban design runs counter to the economic forces underlying both the economic and cultural aspects of globalisation.

Jeremy Rifkin argues further that the capitalist journey, which began with the commodification of space and materials, is ending with the commodification of human time and duration. "The progression in economic priorities from manufacturing goods to providing basic services to commodifying human relationships and finally to selling access to cultural experiences is testimony to the single-minded determination of the commercial sphere to make all relations economic ones." [RIFKIN 2000] He argues that through networks of leases, partnerships, subscriptions and retainers, all time is commercial time. Cultural time wanes, and humanity is held together only by commercial bonds: this he sees as the crisis of post-modernity.

Atkinson, in his concluding chapter on *Principles of Political Ecology*, attempts to look beyond post-modernism to an "ecological future". He points out that in a world dominated by competing vested interests, the future is inevitably contentious, and that it is improbable that a "more conscious and open utopian speculation and design of the future will find easy acceptance." [ATKINSON 91] He observes that it is rather contradictory that a society that believes so strongly in promoting change at the same time suppresses any broad, conscious consideration of the future. He attempts to explain this in terms of enlightenment ideals, where the individualistic nature of society eventually – but not yet – matures into a more mutual or collective rationality. This explanation is similar to other arguments that reference the concept of self, and the modern emphasis on individual time rings, as the key impediment to long-term thinking and design.

2.2 What is Scientific Time?

G.J. Whitrow in "The Natural Philosophy of Time" undertakes to explore in detail the time concept from many scientific perspectives: universal, mathematical, astrophysical, biological, and relativistic. He concludes, simply, that time is a fundamental characteristic of the universe. "The very essence of time is its transience, and this is a fundamental concept that cannot be explained in terms of something more fundamental." [WHITROW 80] Time and physical reality are interdependent, parallel characteristics of our universe. Time is the mode of activity, and without activity there can be no time. In this sense, scientific time is an inherent factor in all cosmology and technological change. Time is necessary as a way to explain physical phenomenon in the universe, and to express causal connections upon which the scientific method depends.

Other writers have explored much more thoroughly the role of prediction and time concepts in science. Sorokin categorises four types: metaphysical, physico-mathematical, biological and psychological. [SOROKIN 43] Most of this literature on scientific time has limited relevance to urban system design. However two notable exceptions are (1) entropy, or the apparent asymmetrical structure of time in the physical world and (2) syntropy, the anticipatory, evolutionary features of life systems.

2.2.1 Entropy and Syntropy

Entropy and Time

Entropy refers to the second law of thermodynamics, which simply stated, holds that heat does not pass from a colder to hotter body. Carnet, who in 1824 first described this feature of the physical world, coined the word entropy from the classical Greek for 'a transformation' - although neither the Greeks, nor any pre-modern civilisation had ever observed the second law. Embellished by Clausius and Thomson in the 1850s, and still later by Lord Kelvin, the second law argues that although energy within a closed system can never be lost, it may become unavailable for doing mechanical work. Every activity results in the dissipation of heat, and a corresponding increase in entropy as systems move towards a thermodynamic equilibrium. Energy's diffusion, dissipation, or dispersion in a final state compared to an initial state is the driving force in chemistry. Entropy is the index of that dispersal within a specific system.

Since every action increases the net entropy, the world as we know it appears destined to dissipate all energy, and become uniformly dark and cool - at least until the next 'big bang'. Thus entropy is a term that may be used broadly to refer to the irreversible winding down of the universe – the 'one-way arrow of time'. The concept of irreversibility was very reluctantly accepted by modern minds. Even novel thinkers like Bertrand Russell found entropy repugnant, complaining about the 'unyielding despair' created by a science that tells us: "That man is the product of causes which had no prevision of the end they were achieving; that his origin, his growth, his hopes and fears, his loves and his beliefs, are but the outcome of accidental collocations of atoms; …that the whole temple of Man's achievement must inevitably be buried beneath the debris of a universe in ruins…". [RUSSELL 59]

Both eastern and western philosophers have always subscribed to some variant of a cyclical universe governed by the 'eternal cosmogenetic processes'; in other words human culture has always included a stable world view, characterised by repetition over the long-term. The second coming of Christ is to be a change in governance and not an end to history – the new arrangement is intended to last for another millennium or two, and then for eternity in heaven. In ancient Hindu cosmology the universe is created, destroyed, and re-created in an eternally repetitive series of cycles or Brahma days, each 'day' lasting 4,350,000,000 years. The temporal cosmology of Buddhism is also cyclical and eternal; a great eon of billions of years is sub-divided into four kalpas and then further sub-divided; each kalpa is destroyed according to a sequence, by fire, water or wind, as the world is repeatedly and eternally dissolved and reborn. The irreversible nature of entropy appears to contradict these mythic and universal world views.

More recent scientific theory qualifies the concept of irreversibility by exploring the nature of knowledge and the relativity of time. Einstein applied Galileo's relativity theory with the new thermodynamics - particularly that the speed of light is a constant. The net effect was that what varies is time: time flows slower if the event is happening in the direction towards which we are moving, and faster if the event is happening in the direction to which we are coming. Thus for any shared reality to exist among a group of randomly moving people, past, present and future must co-exist.

The mathematics of energy and mass suggests that time must flow in reverse: $e^2 = c^2 p^2 + m^2$. The p is momentum which at the atomic level is never zero; thus e is always the product of a square root – which can be both positive and negative. Hence time is reversible. A solution which travels forward is called retarded potential (the basis of entropy). A solution which travels backward is called advanced potential. Modern physics leads to views of time that seem to contradict all other concepts of modernity.

Danah Zohar, in her book on the *Quantum Self*, remarks upon the great distance between contemporary physics and the actual assumptions of lay persons in contemporary culture. She argues that the concept of 'being' as an indeterminate wave/particle dualism, the concept of movement which rests on virtual transitions, and the concept of non-locationality (or instantaneous action at a distance) are all still viewed as mystical concepts. Yet they define very real physical phenomenon at the sub-atomic level. In her view the observations of quantum physics presage a revolution in our cultural perception of time and how things relate. [ZOHAR 91] Similarly, Robert Rosen, a biologist who helped to initiate research into 'feed-forward' systems and anticipatory futures, argues that, in a fractal way, the concept of entanglement at quantum scales may explain mind as an emergent property at the macro scale. [ROSEN 85]

Syntropy and Time

Entropy applies only to closed systems, where no input or output of energy can change the overall state. Life systems however, are open systems where inputs of solar energy (indirectly or directly) sustain the biomass and information (genes) over time. It is because life systems are open that they are not constrained by the law of entropy and need not dissipate over time. Interestingly, when life systems are observed over time, they exhibit emergent properties – a sort of progression – that like entropy represents another one-way arrow of time.

In 1942 Von Bertallanffy identified four essential attributes the define the progress of complex self-regulating systems like ecologies: (1) integration, (2) differentiation, (3) mechanisation and regulation (or feedback) and (4) cooperation (to achieve synergies at multiple scales). [JORGENSEN 2006] Since Von Bertallanffy a major effort has been made to account for the dynamics of energy flow and storage in life systems. Seminal work by Howard Odum in the 1960s and 70s – with help from D.M. Scienceman in the 80s - provided a set of protocols, terms and units for tracking energy and power in complex systems, and converting total energy values into common units such as solar energy. [ODUM 69] [SCIENCEMAN 8] Odum's measurements allowed for a more precise exploration of the trends followed by all life systems, trends such as increasing biomass, energy flow and information storage over time. Since Odum's first attempt many others have used these concepts to define driving forces and conditions that might explain and predict the behaviour of life systems with respect to basic thermodynamics. C. Giannantoni has gone so far as to propose a 'fourth law of thermodynamics', based upon the observed tendency of ecological systems to maximum total energy throughput over time. Such a law cannot be directly measured, and is one example of how the study of life systems has generated an on-going debate over the existence of new thermodynamic principles. [GIANNANTONI 02]

In a recent paper on *Complementarity of Ecological Goal Functions*, Brian Fath, Bernard Patten and Jae Choi have reviewed the evolving science around the organising principles of ecologies, and have attempted to resolve differences by means of 10 comprehensive organising principles. These are the goal functions - minimum or maximum values that orient behaviour of ecologies – that can be used to model performance. The 10 "principles can be summed up in the following maxim: Get as much as you can (maximised input and first passage flow), hold on to it for as long as you can (maximise retention time), and if you must let it go , then try to get it back (maximise cycling). They argue that the complementarity and interdependency of these functions has made the identification of a single universal principle – or law – difficult. [FATH 2000].

Luigi Fantappiè (1901-1956), an Italian mathematician, proposed that the emergent properties of life systems are governed by laws that are fundamentally different from the traditional science used for predicting physical events. While working on quantum mechanics and special relativity, Fantappiè argued that all physical and chemical phenomena, which are determined by causes placed in the past, are governed by the law of entropy, while all those phenomena which are attracted towards causes which are placed in the future (attractors), are governed by a law which is symmetrical to entropy and which Fantappiè named syntropy. The existence of attractors requires that science be widened to include to the study of phenomena which cannot be caused, - phenomena which we can observe, but not reproduce in a laboratory.

Until the debates began on progression of life systems, it was generally accepted by science that all phenomena were based on causal relations and that every aspect of reality could therefore be studied using the experimental method. However what makes life systems different from all others is the presence of syntropic qualities: finalities, goals, and attractors (or orientors). If past causes are the essence of the entropic world, then future causes – or finality - become the essence of the syntropic world. From this perspective, the law which dominates life systems is the law of finalities, or in Fantappiè's terms, the law of syntropy.

Antonella Vannini attempts to explain why the law of syntropy is so poorly understood among scientists today. Researchers find it impossible to manipulate syntropic causes, because these causes are placed in the future, and as a consequence they find that it is impossible to study syntropic relations with the experimental method. She points out the need for a new methodology which could allow "scientific studies of syntropic relations and qualities." [VANNINI 06] Presumably such new methods must be capable of modelling complex systems with many competing functions, and it is hard to see how the law of syntropy will ever have the power and simplicity of the laws of thermodynamics.

Rosen has also explored the missing methodology for life systems. He argues that anticipation flies in the face of science as we know it, which relies on the belief that events are not arbitrary, but obey definite laws which can be discovered. The continuous search for laws in science is an expression of the deep faith placed in the fundamental concept of causality. However according to Rosen, a full understanding of life systems is not possible by searching for laws based upon causality. Rather life can only be understood by beginning with the organisation and function of the original system. Structure and physical detail then become realizations of the relational properties held in common by large classes of organisms. [ROSEN 85]

Given the tremendous diversity of life forms on this planet, it is the characteristic relational properties which provide the only common thread or means of identification of living organisms as separate from the inorganic. Rosen's 'relational biology' is much different from the familiar analytical, experimental approach that has been the cornerstone to biochemistry and molecular biology. He emphasises the importance of the relational approach to the field of human planning, and particular to the "immanent cataclysm" that may result if we fail to improve management and the systematic implementation of specific plans, programs, policies and strategies. The dominant scientific model sees only the anarchic or entropic processes, which are then inappropriately imposed upon planning and design methods.

Rosen's alternative is to focus on anticipatory behaviours. An anticipatory behaviour is one in which a change of state in the present occurs as a function of some predicted future state, and that the prediction is based upon a 'model' in the broadest sense. Most non-routine behaviour is anticipatory – that is it is based upon some kind predictive model. Adaptive behaviour by instinctual animals is also based on anticipatory models, albeit hard-wired. Thus models lie at the root of organic systems, from the molecular scale to the societal, from the survival behaviour of organisms to the theory of evolution. All relational characteristic of life systems can only be understood in terms of final causes.

For biologists, evolution refers to the phylogenetic process that makes organisms better adapted to their environment over the long-term. Although the understanding of evolutionary processes is now much different than what Darwin first described, the basic direction of change implied by evolution has not been disputed. Simply stated, organisms that change to promote their welfare, or the welfare of their species, are more likely to survive, and to reproduce efficiently. Thus as species mutate or learn, the automatic tendency is for natural selection of those organisms that are ever more adapted in terms of obtaining food, avoiding predators, surviving shocks, and satisfying a whole range of biological needs. The process works at various scales. Communities of organisms that co-evolve create partnerships or whole ecosystems that optimise the welfare for groups of individuals. This dynamic can occur even at the global scale – the Gaian hypothesis.

In physical terms, co-evolution means that over time, communities of species adapt to capture greater amounts of energy from external sources, and that they use the energy more efficiently, by cascading it through many species as it degrades. Thus the evolutionary process increases the total energy flux or entropy, usually with a corresponding increase in both the total biomass and the total 'welfare' of the community. While occasional freak mutations may reverse the direction of adaptation, the long-term evolutionary process appears to be irreversible. The process is governed by a number of principles, as outlined by Fath et al, which in combination reflect the attraction of life systems to optimise welfare over time. Evolution is the long-term consequence of the of the law of life systems, or syntropy.

Evolutionary time periods may be very long. With reference again to the time rings of Freeman Dyson "… we see that it takes about 10^6 years to evolve a new species, 10^7 years to evolve a genus, 10^8 years to evolve a class, 10^9 years to evolve a phylum, and less than 10^10 years to evolve all the way from the primeval slime to Homo Sapiens." [DYSON 79] Underlying all of this adaptation and optimization is a one-way phenomenon that depends upon anticipatory models operating at all scales. As humankind grapples with the great challenges of urban sustainability, perhaps this view of life as a modeling and future-directed science can help to provide a foundation for more appropriate timing tools and methods for design and decision-making.

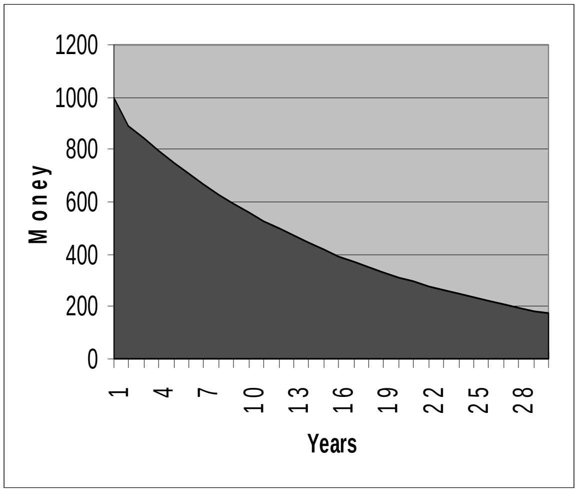
2.2.2 Economy and Ecology

Another source of confusion and potential innovation within the scientific time concept is the differing valuation of time by economists and ecologists. Both of these disciplines study of how scarce resources are allocated amongst competing uses. Both disciplines rely on observation and prediction to facilitate discussion of the current understanding of the operation of life systems, and both strive to develop controls based on systems modeling and accumulation of data and knowledge. Yet the differences are still very large from a systems perspective, and most especially in how these two professions address time.

Economic Time

Economists, following the actual practice of buyers and sellers in the marketplace, discount future value to arrive an equivalent present-day value. All humans tend to discount the future – and in so doing reflect some amount of time preference as befits their impatience, the scarcity of time (the individual's mortality), and the inevitable risk and uncertainty introduced by delay. Consequently once time is considered in any type of economic valuation, some degree of discounting is normal. Discounting can also be justified from a strictly economic perspective, by accounting for the marginal productivity of capital. A sum of money invested today, at a reasonable amount of interest, will compound and grow to a larger sum in the future; hence money or resources that can be accessed today – are logically worth more than money or resources that are reserved or made inaccessible until some time in the future. Stated in other words, resources in the future are worth less to entrepreneurs in the present, and thus need to be discounted in order to be expressed in present day terms.

Figure 8 shows both the typical economic formula used for discounting, and the result of using this formulae to apply a typical money market discount rate of 6% on the present value of future assets. A time horizon of 30 years has the effect of reducing the value of final results by more than 80% in today's money. Thus long-term strategies are prima facie economically irrational. Discounting is widely used as a rational solution to the social problem of making inter-temporal comparisons of welfare, either in the marketplace, or as part of other investment and assessment procedures.



$$FV = PV\,(1 + i\,)^n$$

FV = Future Value
PV = Present Value
i = the interest rate per period
N = the number of compounding periods

Figure 8 A standard market discount rate of 6% makes any long-term asset of negligible value today, and effectively eliminates any economic rationale for long-term assets

Despite its almost universal application, discounting is a crude timing tool and even economists disagree about the correct applications. Writing in **For the Common Good**, Herman Daly provides a critique of discounting as viewed from the perspective of economic and social welfare. His first criticism is that the discount rates derived for individuals make no sense for decisions made at the community level – a step up the time rings. In comparison to the individual, the community is 'quasi-immortal' and thus time is not scarce. Also, the social decisions are not subject to the same vagaries of the market, and thus the uncertainty is less. His second criticism regards the concept of discounting future utility or happiness. "There is no real world operation by which satisfaction today can be stored in a fund and even if there were, there is no reason to expect such a fund to grow to give greater satisfaction tomorrow." [DALY 89]

His third criticism is that a discounted present value does not actually promote sustainable long-term decision-making because it does not reflect the welfare of future people themselves, or even our estimate of their welfare; rather it reflects how much we care about other people compared to ourselves. It is difficult to know whether future people will benefit from increased knowledge and more productive technology – and therefore can be satisfied with less utility or asset value – or whether they might find themselves overwhelmed with ecological disasters and the consequence of short-term profiteering by people today.

Daly also questions the use of money as a surrogate for environmental services since the environmental services are constrained by fixed limits, while in theory any amount of money can be placed in a bank account and grown to whatever size is indicated by the interest rate selected. Finally Daly articulates the ultimate critique of discounting applied to ecological resources, citing the problem of "economically rational" species extinction. Any commercially valuable species that is not too expensive to capture, and whose rate of reproduction for all population sizes remains below the interest rate, will be exploited to extinction for economic optimisation. If interest rates represent an average rate of biological productivity, then the large majority of species that are easy to harvest and yet reproduce at rates lower than average are doomed.

David Pearce, another economist who like Daly has worked on these issues for the World Bank, has conducted a comprehensive review of arguments for and against economic discounting. [PEARCE 93] [MARKANDY 91] Pearce and his colleagues recognise that the "tyranny of discounting" represents a major obstacle to environmental sustainability, and that discounting is in some ways unfair and unreasonable. Like Daly, they recognise that it is philosophically wrong for society to discount wants based upon a time variable – all wants are in the future and what matters is the satisfaction of wants as they arise, period. They also recognise that social time preference is now heavily influenced by poverty, and an expectation that consumption will grow in the future. However poverty is often a consequence of the environmental destruction associated with consumption, and increased spending today may only worsen poverty in the future.

Pearce also criticises the standard economic rationalisation based upon capital productivity. Since discounting is applied to resources that are consumed today, and not actually invested, the issue is only the flow of resources, and any presumed growth in capital is in fact fictitious. Like Daly they agree that it is unreasonable to use social time preference rates established by individual decisions for policy that applies to the society as a whole, which is deemed immortal. They question the use of risk as a justification for discounting, since many environmental policies are in fact designed to reduce risk in the future; moreover risk and uncertainty do not necessary change with time in any consistent fashion.

As part of his critique Pearse et al also identify many spurious arguments against discounting. For example they point out that no unique relationship exists between high discount rates and environmental damage. High discount rates reduce investments, including those that might damage the environment. They also argue that if the benefits received from investments made today are not reinvested to provide value for future generations, this is not a problem with discount rates per se, but with ethics and public policy.

Most importantly from the perspective of this thesis, Pearce concludes that it is not practical to try to change discount rates as a means to achieving sustainability. He points out that it would be virtually impossible to impose differing discount rates across the marketplace for different types of investments. Moreover desperate levels of poverty and strife worldwide are likely to continue to distort discount rates regardless. So he concludes that new discount rates are not the solution, but rather new tools for addressing long-term values. In this sense he arrives at a similar prescription for economists and policy makers as that explored herein for design professions. The new tools he proposes are only described briefly and constitute principles for decision-making. Basically he proposes that a new, strong public policy be established for protecting the natural resources base against damage from economic development. The policy would be implemented as a 'constraint' on investment. The constraint would stress the importance of valuing environmental assets and their services; the need to ensure that investment truly build up the stock of man-made capital, and the need for minimum standards in situations where environmental capital is judged to be 'critical'. It is still not clear how such a constraint might be operationalised, although the move in some developed countries towards a national accounting system for stocks (natural capital) is a first step.

Daly also concludes that a sustainable economic solution cannot be achieved by simply altering discount rates. His solutions for new timing tools are many, and cover all aspects of society. The basic alternative he promotes is firstly a growth of 'community' as a counterbalance to the potentially destructive implications of individual decision-making. He would see an urban region function not as one cosmopolitan area, but rather as a 'community of communities'. By regenerating the social connections of groups' of people, it becomes possible to think longer-term. This type of solution is germane to urban design processes – extending the time rings.

Daly's other primary strategy is to rethink economics itself, and introduce a new way of valuing and protecting resources like land and other the sources of long-term wealth, along with a new process for defining and measuring economic welfare. This solution is very ambitious, but not without support. Daly's work has contributed significantly to the birth of ecological economics, where the entire economic system is deconstructed and re-positioned as a sub-set of the environmental systems in which all wealth generation and allocation principles are embedded. [COSTANZA 91] [REES 91] In temporal terms, ecological economics is a powerful tool for changing time preference. By conceptualising the economic system as nested within the nature ring, economic time converges with ecological time.

Ecological Time

From an ecological perspective the long-term value or integrity of the system can be defined by its ability to continuously provide the ecological services upon which humans (and other species) depend. Time periods are defined on a contextual basis where the organism or dynamic under investigation provides the temporal scale, not the human needs or values. Each object within the environment has its individual time, and a class of similar objects has a generalised time or time archetype, providing ecology with a concept of time which is built up of qualitatively different periods, which are inseparable from the science itself.

The strength or robustness of an ecosystem depends upon the interaction between the nested time scales for the 'keystone' species that maintain order within the system, and that contribute to the succession of events that allow the system to evolve and adapt. Figure 9 shows time rings from an ecological perspective, with a example mix of keystone species. The time scales for keystone species can range from months to centuries – the horizontal axis is logarithmic time. From this ecological perspective, discounting of time makes no sense, and is not a concept that is used. Rather the challenge is balancing short-term and long-term processes across the time rings.

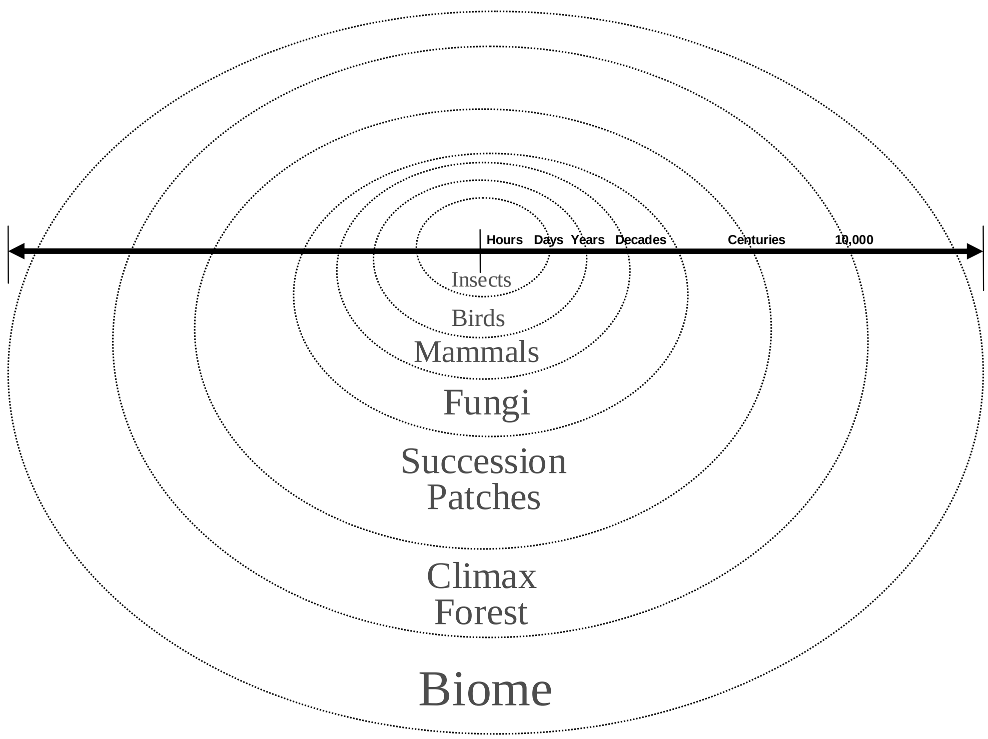


Figure 9 Long-term health for ecologies is achieved by the interaction between keystone species located in different time rings

(logarithmic scale) [adapted from GUNDERSON 01 and redrawn by author]

Ecological time becomes important as a way to describe how a mix of species with differing lifetimes helps the system as a whole to survive changes that are outside of control. Some species respond quickly to change and shocks, others more slowly. The time rings allow the system as a whole to be reconstructed at any time scale, should gaps occur. Fast species are discontinuous, slow continuous. Fast responds, slow remembers. [BRAND 99] Brand claims that all durable and sustainable systems have this sort of structure; it is what makes them adaptable and robust.

2.3 How are Time Concepts Changing?

The transition from land-based societies to modern economies is a process that continues to transform the time concept in fundamental ways. Some of the different perspectives on how time moves are visualised in simple graphic forms in Figure 10. Mythic time is cyclical, sacred, textured and stable. Modern time is linear, secular, progressive, homogeneous and standardised. Post-modern time has a less certain past and future, is less progressive, and more extended. Ecological time recognises the inevitability of failure and fundamental limits to growth, and re-introduces a series of interim cycles, en route to a steady-state. In societies today many of these time concepts may co-exist.

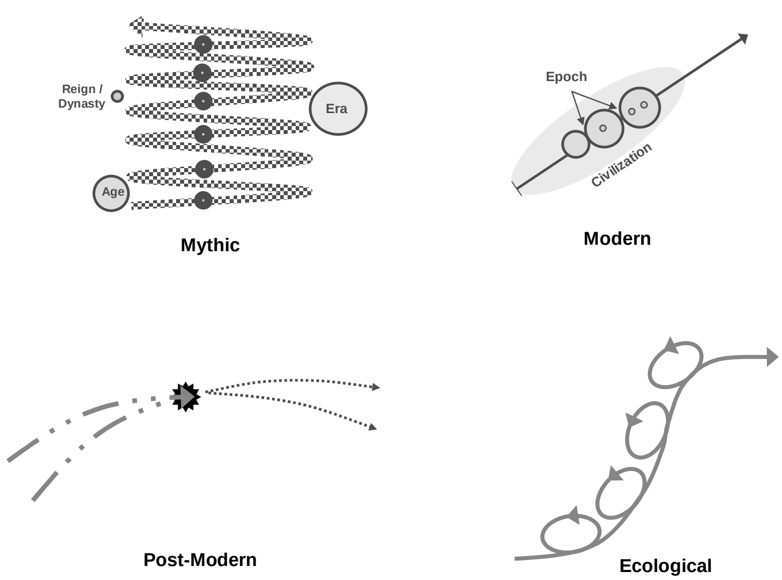


Figure 10 Very different views of time have emerged through history and continue to co-exist

These highly simplified illustrations provide a context within which it becomes possible to explore important variations in time concept within contemporary culture, and especially urban design. Figure 11Figure 11 illustrates how a 'sustainable time concept' might be constructed by combining the concepts of growth and stability at varying scales in a fractal pattern. This image incorporates three concepts which may need to work in combination: time extensions, time rings and time cycles.

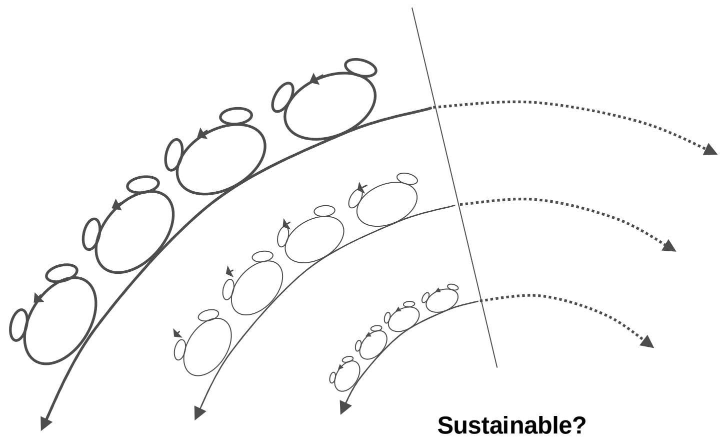


Figure 11 A more sustainable time concept may combine time extensions with a cyclical pattern of growth and decline at varying scales from very short to very long.

2.3.1 Time Extensions

The future has traditionally been a period sufficiently remote that it can safely harbour problems that seem intractable in the present. However the new environmental reality is a world system in crisis, and a technological system that is driven by accelerating innovation and long-lasting impacts. For these reasons, Helga Nowotny argues that the future is no longer the attractive and remote catch-all for impossible dreams and intractable problems. The future is here with us today. It has become part of an extended present. "The future no longer offers threat projection space into which all desires, hopes and fears could be projected without many inhibitions because it seemed sufficiently remote to be able to absorb everything which had no place or was unwelcome in the present." [NOWOTNY 94]

The scale and impact of the human enterprise continues to draw the future closer to the present. In some ways the future has been disposed of in the present. For example the future cannot easily be referenced in language as a vague intent for action: I wish to 'invest in the future'. Rather the future is now presented as a rational consequence of our actions in the present.

The abolition of future, and its replacement by an extended present, is not necessarily a problem. It is just a dynamic – a change in time concept that accompanies a globalised economy and an environment in crisis. Sustainable design may contribute to this change in time concept, insofar as long-term visions of sustainability can be clearly translated into pathways and strategies for redirecting action in the present. The more sustainable the design, the more the future becomes part of the extended present. Alternatively, it may help to stretch or extend the time horizons until, at last, we re-create a future where anything is still possible.

Time preferences ultimately impact the allocation of time resources by individuals, as they choose between physical and spiritual goods, choice of work, social policies, legal systems and living environments. The ability to defer gratification and invest in sustainability – a low time preference – is influenced most strongly by a secure family environment, interpersonal trust and the feeling that the waiting indeed will have payoffs. Beginning sometime in the 1970s, at least three substantial societal forces have undermined such factors, and increased time preferences in design and decision-making. The three forces include debt-based economic models (1), promissory politics (2), and globalism (3). While these forces may benefit specific groups and also achieve specific societal goals, their cumulative effect appears to be a shrinkage in time horizons for all decision-making, despite the increasingly long-term impacts. The short-termism that results is a paradox in governance, and may represent the single greatest obstacle to sustainability in design. An exploration of the forces responsible is outside the scope of this thesis. However a brief discussion is warranted in order to set the stage for alternative time preferences in urban design and decision-making.

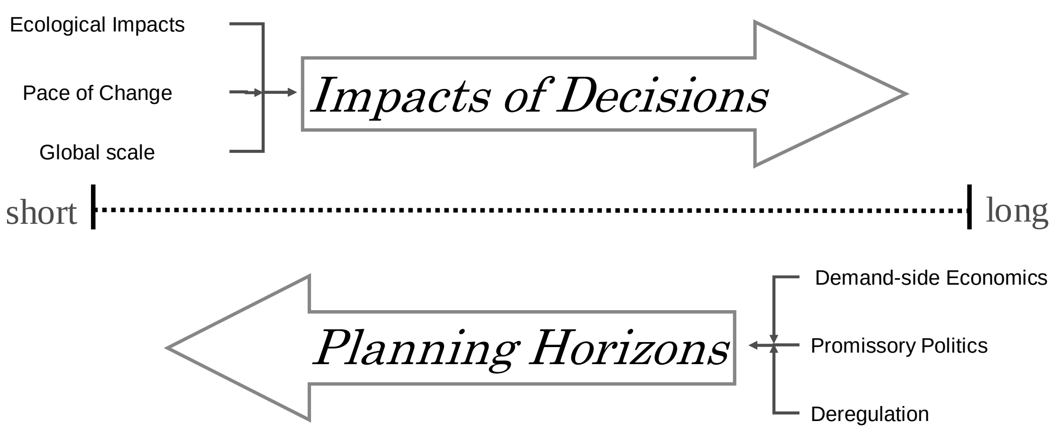


Figure 12 A paradox of governance is occurring when time horizons appear to be shrinking despite the increasingly long-term impacts of decisions

1. Debt

The modern world is now characterised by debt-based economic models that encourage a high time preference for nation-states, provinces, cities, private corporations and individuals. Never have debt levels been so high. Average personal debt loads in Canada are up 36% in just the last 10 years, after adjusting for inflation[1]. Since 1985 the percentage of wages saved – the saving rate – has dropped from 15.8% to 1.4%. "According to the latest estimates for 2005, spending is now above the actual level of disposable income. On average, households are now putting nothing away for a rainy day, for a bout of unemployment or for retirement." [SAUVE 06]

These trends are worldwide, although the size of debt loads vary considerably. The almost universal application of neo-Keynesian economics provides one philosophical justification for public debt and, by implication, for a high time preference by consumers. According to the philosophy, short-term interventions are justified to stimulate demand and employment, even if at the expense of saving and investment. Growth-based economies tend to encourage 'hyper-accumulation' as stimulus for creating jobs and wealth are a variation on the same 'buy now, pay later' philosophy. The assumption that debt is a necessary antidote to economic and personal problems is shared by people from all walks of life. Almost everyone hates high interest rates for example – something that would not be true in a spendthrift, asset-rich world.

Alexander Smith, writing in his book *Time and Public Poli*cy, argues that this rising time preference is a post-modern phenomenon that runs contrary to the time concept that prevailed under conditions of industrial capitalism. His study of early capitalism suggests that the 'Economic Man' of classical political economy, when left to his own devises, will orient activities to the long-run and to the community values. The bourgeois ethic traditionally placed much store in such virtues as patience, abstinence, and thrift. Hard work and diligence were a way of life and religiously meaningful, as each man sought to augment his capital and the position of his family. [SMITH 88] Decision-making was family-centred, to the extent that savings for children, and capital accumulation – not consumption – were idealized. These values were embodied in the Calvinist ethic and also within the Catholic groups forced out of Italy and Flanders into Switzerland and Holland during the beginning of the capitalist era. Their value system provided impetus for growth of mercantile capitalism, and as Max Weber has argued, may have been a prerequisite for the birth of mercantile capitalism.

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[1] Bank of Canada

From the perspective of time rings, the bourgeois ethic was integrally bound to loyalty to family and this helped to balance the time preference and the ability of society as a whole to invest in the longer-term. A family orientation provides time scales of at least three generations, and creates capital, assets and wealth. While even longer time scales are required for sustainability in design, the point is that time scales are now shrinking, not stretching. The Bourgeois ethic declined as the entrepreneur was replaced by men and women working in a largely secular and pluralistic society, within larger organisations, and with the security of impersonal trade associations, and the welfare state. It was no longer an imperative to persevere, acquire assets, control property, achieve independence, and control fate. Instead the modern version of 'economic man' tends to live more for individual and immediate satisfactions, with the expectation that tomorrow will be taken care of automatically. Corporatism, in one form or another, creates a broad political and economic umbrella that brings together state and large corporations, and reduces societal expectations for individual responsibility and action.

This progression is now being echoed throughout the world as family and religious-centred cultures move relatively quickly into and past industrial capitalism. South Korea is an example of a country in rapid transition, moving from a wholly agrarian economy in 1962 to what is now the 11^{th} largest economy in the world. Until recently the country's financial institutions provided no mortgages and it was up to families to ensure that young people could afford a home. Hard work was an ethic and also a point of honour for a shared family identity. When the Asian currency crisis damaged the region's economy in 1997, both the South Korean government, with help from media companies, requested that citizens assist their country by turning in gold jewellery. Many people from all ranks of society reportedly waited in lines at city halls for hours to contribute their wedding bands and other jewellery - an attitude to wealth and community that reflects their very recent past as a pre-industrial, Confucian society. [DECWEB 98] Such loyalties are likely to be undermined by the debt-driven lifestyles that tend to accompany urbanism and consumerism.

2. Promissory Politics

In the past 500 years a universal world order reinforced by a religious society has been replaced by rationalism and a political process that focuses on the rights of individuals and social welfare. [SAUL 92] The spread of this political process to most large and populace countries in the developed world has meant a form of democracy dominated by experts, working in on behalf of political parties. The parties are designed to obtain and retain power. This generates a competition to convince swing voters, most of whom are demanding greater economic support from the state for championing movements based upon special interests - race, class, gender, sect and sector. To meet such demands, policies are designed to extend privilege, equalize results, and redistribute wealth. Such policies do not directly address community assets, natural capital, or the overall value of savings and investment. Smith describes this process as 'promissory politics' by which he refers to the tendency for elections to become vote-buying exercises in which opposing parties compete by promising a greater share of the collective pie to the swing voters. [SMITH 88]

Although notable exceptions exist, contemporary democracy world-wide is driven by the short-termism of promissory politics. This is of course an improvement over the arbitrary decisions of totalitarian rulers, and the unchanging, hugely inequitable systems that led to the revolutionary changes in Russia in 1917, or France in 1879. But it is no substitute for long-term decision-making. From global to local, the horizons for design and decision-making seem to be shrinking with the spread of democracy. For some mayors and councillors, it is now difficult to think beyond election cycles of 3 to 4 years - a time horizon more typically associated with the private sector. [2]

In their book on *Shaping the Next One Hundred Years* Robert Lempart and the other members of the RAND team cite a few examples of long-term policies that have successfully achieved their goals. They cite the 40-year strategy of 'containment' that was implemented by the west during the cold war, and the North American investments in railroads as a means to build nations and enable a continental industrial economy. [LEMPART 03] The Marshall Plan might be another example. Perhaps an increasing pace of change, and an increasing complexity in economic systems, has undermined capacity for long term strategies of this type. But the leadership required for such long-term decisions is unlikely to emerge as a product of political systems dominated by parties controlled by swing voters. Even in the face of potential for cataclysmic climate change, countries like the USA persist in defending the short-term interests of special interest groups.

3. Globalism

Globalism is an ideological force predicated on the assumption that the power of the nation state is on its way out, to be replaced by that of global markets. It is a philosophy that has rationalised and facilitated the globalisation of world economies since the mid 1970s, and for many years underlay the international policies of powerful western nations and of global institutions such as the World Bank. As an ideology Globalism is now challenged throughout the world, and can no longer be described as the

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[2] Personal discussions with mayors in major cities across New Zealand, 2006-12-04

dominant ideological force in economic policy. [SAUL 06] However globalism has great momentum in many parts of the world, especially the rising Asian economies, and in combination with other forces continues to increase the time preference of decision-makers.

Globalism argues that economic forces must play a greater role in directing human events. According to theory, freed markets will establish natural international balances, less vulnerable to boom-and-bust cycles. The growth in international trade, as a result of lowering barriers and deregulation of local markets, will unleash an economic-social tide that will raise all ships, north and south alike. Prosperous global markets will turn dictatorships into democracies and discourage irresponsible nationalism, racism and political violence. Large trans-national corporations will be less vulnerable to bankruptcy, and free from local political prejudices. The decline of national politics will be an antidote to local pride and political manipulation (promissory politics), and force the emergence of debt-free governments and stabilised societies.

With this as public rationale, a concerted effort has been made to lower barriers to trade. Money markets have opened to speculative investments and industry has decentralised its operations. Accelerated by telematics, and cut loose by government deregulation, the mobility of capital and fluidity of capitalist relations of productions have brought an entirely new dimension to the world economy. [KNOX 95] The resulting increase in the international flow of capital has surprised everyone, and is now estimated to exceed the flow of material goods by five orders of magnitude.

Manual Castells describes how such hyper-speed trading combines with rapid changes in technology to transform the nature of work and the role of time in contemporary economies. Work time is becoming more flexible as the market demands almost instantaneous adaptation. Corporate time is managed as a resource, not under the linear, chronological manner of mass production, but as a differential factor with reference to the temporality of other firms, networks, processes or products. "Only the networked form of organization and increasingly powerful and mobile information-processing machines are able to ensure the flexible management of time as the new frontier of high-performance firms. Under such conditions time is not only compressed: it is processed." [CASTELLS 99]

Deregulation of public assets and public services is a key element of this processing. The effect of such policies and pressures is to remove public input into decision-making, and to force utilities at the national and local scale into a private sector model for decision-making. The loss of security that accompanies privatisation may help to increase efficiency and accountability in the short-term, but it also means that every utility must now focus on short-term profitability, or die.

Lobina and Hall have examined the history of water utilities world wide, and conclude that the vast amount of investment in creating viable public water systems was accomplished by public utilities, after failure by private operators. [LOBINA 2006] They suggest that the current fixation on accountability may come at a major loss, especially for developing countries where considerable new investment is required. It no longer makes sense to retain surplus assets for rainy days, for example – this would be uneconomic. It no longer makes sense to promote efficient use of resources, or to share valuable information on plans and historical consumption – this would be contrary to the interests of shareholders or cost recovery requirements.

Uta Hassler and Niklaus Kohler describe the impacts of privatization and deregulation on all types of urban systems. "Traditional planning procedures are abandoned and replaced by short-term, ad hoc mechanisms with diminishing public (democratic) control." [HASSLER 02] In sum, globalisation seems to inadvertently force public sector urban infrastructure to adopt time preferences as high as the private sector.

2.3.2 Time Rings

The concept of time rings provides a graduated perspective on extended time scales and can be used to place elements of reality within a temporal system. As previously discussed, time rings can be seen as radiating outwards from the present on a logarithmic scale. For example the time rings can represent elements of human identity, from the short-lived cells in our bodies to Home Sapiens to the biosphere, each of which has a different lifetime and hence a different time preference. Or time rings can help to explain the dynamics within an ecological system where the combination and interaction of short-lived and long-lived species creates the capacity to respond to change and recover from losses. Or time rings can represent the various sub-systems that comprise human society and urban regions; the potential for fast and short-term elements - like fashion and enterprise - are constrained by the design features of long-lived infrastructure systems and land use patterns.

Thus time rings offer a simple but important new perspective on time for humanity, as they provide a more systemic and graduated perspective on how time is valued and how elements of urban regions interact over time. Time rings may provide a tool for categorising elements of the built environment, for measuring the balance between fast and slow, and for approaching and organising design strategies – ring by ring.

2.3.3 Time Cycles

Histiography, the study of history as a discipline, may help to explain how the time concept affects the manner in which humans view their world, and how this view adapts to changes in technology and society. Possibly the biggest change in human society ever has been the replacement of gods and myths with modern technology and science. [SAUL 92] As societies adopt a new world view, based upon continuous discovery of newness, innovation and improvement, so too does the concept of history become a linear model of continuous progress. Thus the homogenized time of Newtonian physics reinforces a liner view of time within culture.

The emergence of geological sciences in the late 18th century provides further support for a linear time concept, and also provides a rough measurement for how long it might take to change fundamental world views of time. Until James Hutton introduced the concept of eternal age in his paper to the Scottish Royal Society (1788), the entire western world had never imagined a universe with a lifetime in excess of 6,000 years. The first widely published chronology was by Eurebius (325 AD) and was based upon extensive research by scholars at the Library of Alexandria. Using Hebrew scriptures and ancient texts, their estimate of time passed since creation was slightly less than 6,000 years – a number which not only coincided with the lineage of the prophets, but also with the 6 days required for God to make the earth. In the Bible, specific references equate one of God's days to 1000 years of human time, and thus the in Biblical terms the current millennium (more or less) is the last 'day' when god rests - the Sabbath – the time on earth when God descends to reign.

The Eurebius chronology covered all known peoples (Jews, Egyptians, Assyrians, Greeks, Romans) from the beginning of time to the present, with cross-referencing of the various known calendars. Over the next 1400 years its timeline was not fundamentally disputed by biblical scholars (e.g. Augustine, Aquinas, Luther), nor was it questioned by the scientists of the enlightenment (e.g. Newton). Even the first great geologists teaching in the universities in Europe and the UK in the 18th century managed to shoe-horn all of planetary history into 6,000 years, with elaborate explanations for how the continents were formed by erosion and catastrophes during the receding of a universal ocean – an ocean that represents the waters covering the face of earth on the 'first day' of creation, or the waters from the great flood survived by Noah.

Thus Hutton's theory of subsidence and continuous weathering – combined with 'deep time' – was a radical departure. [GOULD 87] Hutton described a world with "…no traces of a beginning, no prospect of an end." As Jack Repcheck points out in *The Man Who Found Time*, "Copernicus took man away from the divine centre of things, and Hutton took him away from the divine beginning of things." [REPCHECK 03] Hutton's theory was consolidated by Charles Lyle, the founder of modern geology, and it was Lyle's text, carried by Charles Darwin on his first voyage on the Beagle, that first introduced Darwin to the concept of eternal time, and ultimately allowed Darwin to take the concept of divine away from man altogether.

Since Hutton and Lyle posited an 'inestimable' or eternal time horizon, with endless cycles of regeneration, efforts have been made to fit the earth into a more linear, precise and progressive time concept. Over the next 120 years – the modern era – the earth's antiquity has become linear and precise age: 300 Million (Darwin 1850s), 20 to 400 Million (Lord Kelvin 1862), 400 to 2200 Million (Bertrum Boltwood 1907) 1.6 billion (Arthur Holms 1927), 3.3 billion (Gerling and Houetmans 1937), and 4.6 billion (Claire Patterson 1956). However for the human time concept these numbers are just details.

The massive transformation in thinking, from divine cyclical time to linear, deep time occurred over a tumultuous period of only 42 years, from 1788 to 1830, after which even the biblical geologists and catastrophists were forced to accept the Hutton-Lyle view of a world that is effectively eternal. The new chronology of the earth allowed humanity to date the land masses and to sequence and time the history of life. The new time concepts were revolutionary, but they were also part of powerful forces – the enlightenment and rationalism, the scientific and industrial revolutions, the growth of world empire – and even the power elites and traditionalists in the religious institutions had little ability to stand in their way. [NOWOTNY 94]

While chronologies are often used to translate history into something meaningful, the structure itself is only a framework, without content. The impact of the geological framework is significant simply because it replaces cyclicality with a linear and deep view of time. Initially the linear view was also progressive. However as the post-modern era erodes faith in progress, it also opens the possibility for reintroducing cyclicality into the time concept. The pace of change can be understood as a risk, where creation and destruction can occur over and over again. In geology this is consistent with the forces identified by Lyle and Hutton, of erosion, sedimentation, metamorphosis and subsidence. In physics this can be understood in terms of a very long cycle, where the 'big bang' is reinterpreted as a reaction to prior conditions, or as a repeating singularity. In planning and politics, the extended present can now accommodate cycles of innovation, growth and recession that recur over regular intervals.

Kondratiev cycles are an example of how a linear time concept has been modified to include a cyclical pattern in economics and technological change. First posited by Nikolai Kondatriev in 1926, these 'long durée' cycles of boom and bust have occurred over periods of 50-years, beginning in 1789. The waves appear to correspond with transformations in basic technology (cotton gin, Bessemer steel) and basic infrastructure - especially urban transportation infrastructure. [NACENOVIC 88] Joseph Schumpeter and others have kept alive the Kondratiev cycles, using them in attempts to explain the dynamics of innovation and market penetration for new technologies, with each new wave stimulated by the competition and economic depression associated with market saturation. Recent analysis has emphasises the role of resources – especially energy resources – since sudden price hikes like the oil crisis in the 70s can be the initial spark or motivation to explore alternatives and innovate.

The implications of long wave cycles for urban regions can be profound, although difficult to predict. Immanuel Wallerstein has emphasised the correlation between down cycles and social tension – labour unrest, racism, and protest by the underprivileged. [WALLERSTEIN 97] This raises alarms given the increasing disparities in wealth in many parts of the world, including America, and the increasingly multi-cultural nature of urban populations. Just as significant is the implication on economic viability of urban regions, since the long-term cycles have correlated with massive transfers in political and economic power, and with the role of specific urban regions within the global economy. Deindustrialisation and the rust belt cities are an example.

Jeanne Howard questions whether the current theory on long-wave cycles is appropriate for urban regions in the modern world. [HOWARD 89] She points out that the wave cycles we observe from history largely reflect the history of industrialism, and the mind sets of people living in living pre-industrial, agricultural based societies. Will the exponentially increasing rates of change in technology, in combination with information age communications infrastructures and the new paradigm of a networked world, change the periodicity of the basic cycles? If so, shorter cycles are more likely and these would imply even greater vulnerability for urban regions locked into a global economy and the slow-to-adjust elements of local land use and infrastructure.

Another unique situation that may affect cycling is the size and diversity of today's global economy. Economic growth and innovation diffusion may be happening in one location, while another region is suffering from relative decline and obsolescence. Rapid and unpredictable cycles are a threat to designed systems. Urban regions may need to be selective about which large industries are targeted for support and then hedge their bets by developing 'economies of scope' – or networks of complementary industries that share infrastructure and resources. Urban regions may also need to balance the 'global competitiveness' strategies that are now so common, with an investment in community economic development, entrepreneurship, innovation and other elements of self-reliance and adaptability.

Kondratiev cycles are not organic, and do not share the characteristics of natural cycles because they are not periodic, but rather a recurring and predictable sequence of alternating phases. Other types of cycles are discussed later in this thesis when attempting to understand how cities react to changing external conditions such as climate change, plagues, energy technologies and so on. In all cases the waves or cycles provide a kind of language – a time concept - which helps to explain and predict the dynamics of complex human systems like urban regions. The patterns become recognizable only when a long view is taken to history, and then applied to the trends – or linear phenomenon – occurring in the extended present. The scales at which cycles occur may vary from years to decades to centuries. If cycles are interpreted as potentialities and opportunities, they may help to inform the urban design exercise without wholly abandoning the linear time concept.

2.4 The Essentials

Chapter 2 has provided a cursory review of different philosophies of time and some changes that have occurred to the time concept. Fundamentally time concepts are a kind of language that all cultures use to fulfill the social functions of synchronization and orientation. Time concepts evolve in response to changing technology, economics, and politics. By far the greatest changes in time concept have occurred in response to the industrialisation and globalisation of modern times.

It would appear reasonable to assume that new time concepts may be required to allow urban planning and design to remain current with changing cultural values. In fact the review of time concepts suggests that time is an key element of what constitutes social identity and is a reflection of social values. Current economic and political structures appear to suffer from extremely short-term and simplistic time concepts. Designing for sustainability may depend upon new timing tools that can counteract forces now responsible for shrinking time horizons and high time preference.

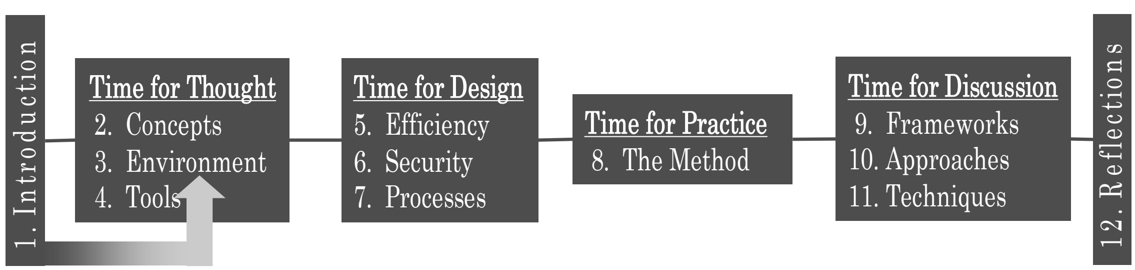
A review of the time concept has indicated a wealth of innovative approaches to re-defining time, from historical concepts, to modern physics, to the study of life systems and ecologies. At the most basic of levels, three timing concepts appear to be especially relevant to future design methods: 1) **time extensions** may reveal the causal connections between current conditions and past actions, and allow designers to project trends and model interactions in the future; 2) **time rings** may help to clarify the different lifetime of elements of a system, and allow planning and design to balance and coordinate time scales; and 3) **time cycles** may reveal the inevitability of changing circumstances, and that allow designers to learn from historical patterns of change.

3 How do Time Concepts relate to the Constructed Environment?

To varying degrees the constructed environment functions as a 'physical clock' that orients people to the time of place. In the most simple of terms, the physical clock provides a coherent chronology, with evidence of where and how people lived in previous times, and perhaps also the evolution in technologies and lifestyle.

Architectural historians have argued that the constructed environment is a mirror of culture – and in fact this is why it can function as a clock. [SERA 01] [NASR 01] As a mirror, it reflects our political economy, social values and world view. And as systems and values change – or remain the same – the slow moving elements of the physical environment remain as evidence, telling a coherent story and orienting the individual to the life history of the larger community. Building architecture, land use patterns, the characteristics of open and green spaces – are always designed to communicate and reinforce societal values, and thus the constructed environment serves to express fundamental aspects of community identity.

In the previous chapter it is argued that the time concept has radically changed in response to changes in culture, and that more change may be necessary to achieve sustainability in urban system design. What will this mean to the functions of the clock and mirror? Can urban design strategies enhance the ability of the urban environment to function as a physical clock – communicating the passage of time over extended time periods? Can system design serve to reinforce a world view that is more sustainable? How do we avoid temporal confusion and disorientation, especially in a period of rapid change? This chapter will explore these relationships and identify the changing role of time in constructed environments.



3.1 How do the Clock and the Mirror relate to change?

3.1.1 The complex relationship between time and environment

To some extent any built environment can be defined as a symbolically encoded cultural meaning system, - a metaphor for ordering experience. The symbolic function of the built environment is mediated by the creativity of the artist and architect within the 'semiotic' context – the syntax and signs available within the culture. Specific design solutions are further constrained by the construction technology and materials, and the climatic conditions.

Certain aspects of the built environment, particularly the form of urban spaces and the land use arrangements, last much longer than the individual designer or owner, and over time they become a reflection and an instrument of social history. King summarises this view: "buildings, indeed, the entire built environment, are essentially social and cultural products. Buildings result from social needs and accommodate a variety of functions – economy, social, political, religious and culture. Their size, appearance, location and form are governed not simply by physical factors (climate, material or topography) but by a society's ideas, its forms of economic and social organization, its distribution of resources and authority, its activities and the beliefs and values which prevail at any one period of time". [KING 80 in LAWRENCE 90]. From this perspective, the culturally defined concept of time must be integral to the design features of all built environments.

The built environments of ancient societies reflected in their form and design a stable view of time. The style of Chinese buildings in medieval times, for example, was dictated down to the number of eaves on a roof, which varied depending upon the owner's rank in society. The precise repetition of the ideal, and the concept of cyclic time, produced a building style less concerned with efficiency than with communicating and reinforcing the social and political status of the owners, the importance of mythical stories, and a devotional loyalty to gods and arbitrary forces.

The pyramids of Egypt are a grand example, given the extent to which their layout and design is basically a physical model of the stars in the night sky at the time they were designed. The pyramids were also designed to function as bridge between the temporal earth and the eternal stars – with escape holes that were literally intended to provide a pathway for the souls of the interned kings and queens to reach specific stars in the royal constellations. In medieval Europe, the cathedral or temple also reproduced the community perspective on the universe as a whole. A cathedral occupied the high ground, representing the hierarchical and central position of God within community. Its shape represented the body of Christ, and its orientation and entrances reinforced the passage to heaven and the mythical stories of the scriptures. The interior was designed and painted to become a literal reproduction of the ideal, with the heavens high above and the mythical saint's chapels circling around the centre, waiting for their special day of the year to come.

Seyyed Nasr, writing in the *Spirit of Cities*, claims that in all places east and west, and in all historic times till the 17th century, the "city itself was conceived to be a kind of reflection on Earth of a celestial, archetypal reality." [NASR 01] Kenneth Olwig, writing in *City and Nature, Changing Relations in Time and Space*, argues that the archetypal city did not simply grow out of market towns but rather originated as a sacred place of worship that was designed at all times to reflect the heavens. "Sacred worship moved from the sacred groves … (Lat. Templum) to the geometrically structured sacred houses of the city (also Templum)." [OLWIG 93]

Amos Rapoport describes how perception, cognition and evaluation are a continuum that give meaning to the built environment. In urban environments memory and stored images are required to notice and interpret differences in form. [RAPOPORT 77] Traditional urban environments can only be understood in terms of sacred meaning and schemata, which define not only high-style tradition but also, to more subtle degrees, the vernacular buildings. As cities entered the more secular commercial era, the high ground gave way progressively to large town houses of the trading entrepreneurs and colonial administrators, and later, in the era of industrial capitalism, to the central business district with its tall bank towers. The organisation of urban environments is less concerned with the sacred, but with reinforcing a new political economy, and with emerging values of "health, recreation, 'humanism', egalitarianism, or material well-being." [RAPOPORT 82]

Denise Lwarence and Setha Low have reviewed the many different theoretical approaches to understanding he complex and histocial relationship between built forms and their associated socio-cultural systems. Some theories focus on social organisation, others on symbolic aspects of built environments (structuralism), psychological aspects and social production. They conclude that in a world that is being reshaped by complex global forces that "penetrate from every angle", the most promising perspective is one that situates built forms within the larger context of society's institutions and its history. They cite work by theorists such as Jean Paul Bourdier, Michel Foucault and Anthony Giddens as providing a basis for reintegrating spatial as well as a temporal dimension into social theory. [LAWRENCE 90]

As cultures change, so too must constructed environments. The dynamic between culture and built environment represents a very complex feedback system: People make cities, and cities make people, and people make cities, and so the cycle continues. The mix of physical elements from the past provides continuity and reinforces traditional values, serving to regulate the pace of change, and to reference new directions. The level of intent or 'social engineering' and the degree of influence from urban design is a subject of much debate.

Kevin Lynch, in his seminal book *What Time is this Place?* argues that the image of the physical environment has been used for centuries as a mental peg on which to hang material to be remembered, and that designers need to better understand human time, in order to better represent time in the environment. "We preserve present signals for the past or control the present to satisfy our images of the future. Our images of past and future are present images, continuously re-created. The heart of our sense of time is the sense of 'now'. The spatial environment can strengthen and humanize this present image of time." [LYNCH 93] He concludes that part of any design challenge is to create a temporal collage – an aesthetic mix of contrasting images that brings the past present and future together. What needs to be explored further is how changing time concepts – extensions, rings, cycles – can be expressed more effectively through such a collage.

Harold Chorney, writing in *City of Dreams: Social Theory and the Urban Experience*, argues that a sense of community depends upon a 'collective memory' of the individuals – essentially a merge of their past – something that has been eroded by industrial capitalism and the urban experience. [CHORNEY 90] Collective memory requires social interaction that is reinforced by physical elements, without which events fade into obscurity – a kind of social amnesia. Chorney cites a number of political writers from the 19th and 20th century who describe the impacts of urbanization on memory and time. Halbwachs, for example, writes: "… every collective memory unfolds within a spatial framework. Now space is a reality that endures: since our impressions rush by, one after another, and leave nothing behind in the mind, we can understand how we recapture the past only by understanding how it is, in effect, preserved by our physical surroundings." [HALBWACHS 1980]

If the clock and mirror provide such important orientation for communities, what happens when space is designed to abolish any enduring record? The bland sameness that typifies so much of the sprawl and mall culture of suburban environments across North America provides almost no clue about the local history or about changing community values. In fact the 20th century is replete with examples of new towns and urban experiments that fail to tell time, and could be described more accurately as attempts to erase time. The dynamics between time concepts and such out-of-time environments are too complex for discussion here. However, in a perverse way, today's out-of-time places may successfully communicate the time concepts of modernity – a time obsessed with the future as a frozen extension of present desire. By truncating history and denying cycles of change, the community is left with an environment that is lacking both in sense of place and sense of time, - a kind of self-inflicted disorientation that reflects and reinforces a modern world view.

A homogenised and timeless environment is now reinforced by the changing role of a global media that is increasingly driven by circulation figures and ratings – and the media is driven by the need to attract attention of large numbers of people. This "attention economy" [FRANCK 03] creates strong financial incentives for promoting a global culture centred on brand names, super stars, new fashion and a constant search for self-fulfilment.

The disorientation is most obvious with the modern city structure, and its self-replicating automobile culture centred on malls, suburbs, freeways and a constantly repeating pattern of chain stores and fast food franchises. This type of urban structure is not so much a reflection of design philosophy and time preference, as it is a self-replicating formula that emerged out of the automobile culture and cheap oil of the 1950s, and that now is replicated by teams of corporations and developers.

Urban-induced disorientation in time is historically linked to the emergence of modernism as an architectural style in the early part of the 20th century. [JENCKS 06] The hygienic, rationalist and bold modernist style was a reflection of the new technologies, of a more egalitarian social structure and of wealthier, unencumbered lifestyles. However it was also an exercise in short-term benefit/cost analysis, which justified the use of reinforced concrete and manufactured products to mass produce floor space at lowest first cost. Seemingly limitless amounts of fossil fuel allowed architects to ignore the time-honoured vernacular and craft traditions that had adapted to the specifics of local materials, climate, hazards and ecological capacity. The only modern constraint became the architect's imagination. The result is a potpourri of styles drawn from different times and locations. Aesthetic considerations aside, these modern components of the clock and the mirror can clash with any surrounding chronology that might still exist, and further confuse time-telling.

Neil Leach draws on the ideas of philosophers and cultural theorists such as Walter Benjamin and Jean Baudrillard to develop a critique of the consequences of the growing preoccupation with images and image-making in contemporary architectural culture. [LEACH 93] The problem with this preoccupation, Leach argues, is that it can induce a sort of numbness, as the saturation of images floods the senses and obscures deeper concerns –

presumably the sense of time among them. This problem is particularly acute for a discipline such as architecture, which relies heavily on visual representation. As a result, architects can become anaesthetized from the social and political realities of everyday life. "In the intoxicating world of the image, the aesthetics of architecture threaten to become the anaesthetics of architecture. In this culture of aesthetic consumption, a "culture of the cocktail," meaningful discourse gives way to strategies of seduction, and architectural design is reduced to the superficial play of empty, seductive forms." [LEACH 93]

Homer-Dixon describes his experience of the exciting and vigorous landscape of the new Canary Warf development in London. In his eyes, architectural themes and ideas are jumbled together. He describes a modernist central tower with pyramidal top that seems to intentionally dwarf the ancient St. Paul's cathedral four kilometres distant; a lower block in neoclassical style, is adjacent to a futuristic printing plant, which stands next to a glass-sheathed office, all facing a treed grand Haussmann-type boulevard; – "each architectural ego raising a meretricious monument to itself…. In this cacophony, nothing prevails, and the rich histories and meanings of each style tend to cancel each other out. The viewer is left with a muddle of motifs – an anarchy of columns, angles, arches, soaring glass walls and thrusting towers that is simultaneously stimulating and senseless. …history had been plundered, and I was walking though a vast dumping ground of trophies seized from the past." [HOMER 2000] He argues that Canary Warf is symbolic of the urban design of economic deregulation in a post-modern world. The same could be said of inner city architecture in Shanghai, New Delhi, Kuala Lumpur, Seoul, and host of other post-modern urban landscapes.

A particularly radical form of post-modern design is now commonplace throughout rapidly developing nations such as China and India. The caché of western association has translated into a mass importation of modernist architectural forms that mix up place and time. In Shanghai many of the high profile commercial buildings have been commissioned from western architectural firms. Around Seoul the new high-end suburban villas in the hilly suburbs are a bizarre mix of imported styles, with Cape Cod cottages next to American ranchers and Canadian platform frame. Hassler and Kohler ague that at the end of the 20^{th} century the ideal of the international becomes predominant in culture landscapes, and that architecture becomes mass culture, creating an 'international region-folklore' whose products tend to replace the time-keeping role of historical monuments – at least in the eyes of the public. [HASSLER 02]

Most urban regions still retain many older styles of buildings which may continue to serve as a physical clock for residents and visitors. The fragments of the old feudal cities within urban regions of Europe are the most visited tourist sites in the world. Their very popularity is a threat to their existence, as they become physically worn out, or as their character is so changed by commercialisation, fragmentation and commodification that they fail to accurately convey information about their past lives.

In this context the many debates about how to refurbish and retain heritage architecture may have bearing on the future of urban system design and management. Clearly heritage buildings, open spaces and monuments serve multiple functions. But is their time-telling function becoming more important in the context of a sustainable design paradigm? If so, how important is the chronology – retaining a threshold presence of styles and uses from different eras? How important are the longer-term stories which may provide a sense of extended time horizons? How can these physical elements be adapted both for re-use and resource efficiency - so they can contribute to community life and sustainable metabolism, while they still tell time?

In a paper on *Urban Life Cycle Analysis and the conservation of the urban fabric* Hassler and Kohler point out that protecting the cultural value of historic buildings may be possible by continuing to protect the isolated monuments which currently represent 1 to 2 percent of the entire stock. [HASSLER 02] However they argue that this approach does not necessarily protect the architectural heritage, nor is it likely to convey those invisible relationships between buildings that create the sense of historical town and neighbourhood. They suggest that monument conservation techniques, which make possible long-term preservation, may need to be adapted to present construction practice, as part of a larger strategy for sustainable management of the existing stock as an integrated part of the cultural heritage. They conclude that historical meaning may be lost if visionary urban design and re-design – as an aesthetic discourse – continues to be overwhelmed by market pressures and the almost universal phenomenon of urban sprawl.

3.1.2 The Application of Time Rings to Urban Systems

As a first step towards sustainable management of building stocks and urban systems, it should be possible to locate urban systems on the same time rings used previously to describe time balances for the physical universe, and for living systems. Figure 13 is an example of the time rings for urban systems, at a very broad level of abstraction. The scale, once again, is exponential. The rings provide a simple heuristic that can be used, for example, to guide the scope and sequence of any design process. At the outside ring are the slowest moving elements – the land base, the local ecologies, the patterns of land use, and the corridors and connections. At the centre ring are the economic purchases and investments that may cycle on a day-today basis, or stretch to reflect payback periods of 5 or ten years. located mid-way on the time rings are the principle design elements of urban systems – the urban stock and infrastructure. This sequence of time rings reflects the estimated lifetimes (or rates of change) for systems and their design processes. These rings may help to balance and sequence decisions, although they may be difficult to apply in practice. No designed system can be isolated from the real world, and invariably the decisions will stretch across all the rings as specific projects move from concept to completion, operation and final disposal.

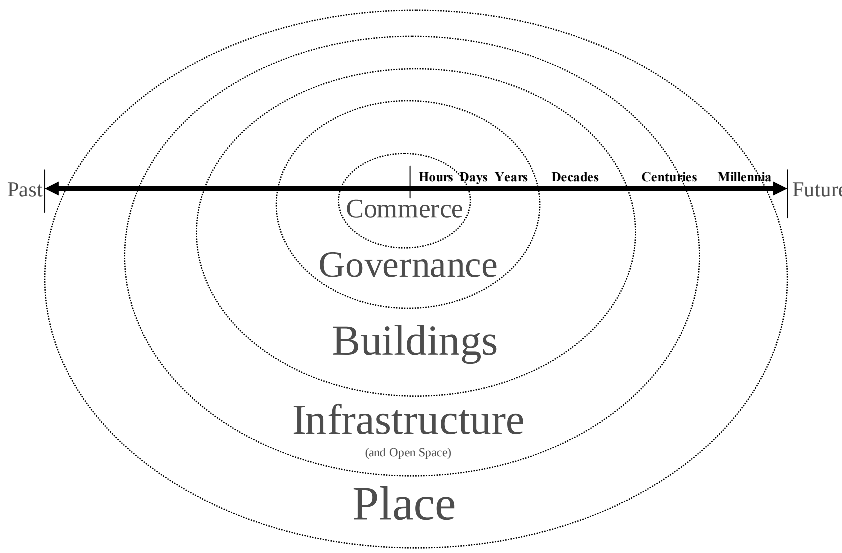


Figure 13 Time rings for an urban region may help to communicate the very different lifetimes of elements (logarithmic scale)

The attempt to place an urban region onto time rings – even at a very abstract level - emphasises the difficulty with estimating lifetimes and operationalising life cycle analysis. The lifetimes of the different systems, each include elements that are long lasting and ephemeral. Even simple elements, from buildings to roads to reservoirs – can have highly variable lifetimes, influenced by a multiplicity of factors. One important factor is the lifetime of the individual component parts. The UK Housing Corporation has developed 'durability rankings' on 3000 unique components used in residential buildings alone. In order to reconcile the often widely divergent evidence on durability, P. D. Mayer has had to correlate a great many related variables, including where the component is used (interior/ exterior); frequency of maintenance and inspections; the design and detailing practices; the nature of installation, commissioning and operation; and the scope of potential causes of failure. [MAYER 05] Durability rankings are also adjusted by the 'service lifetime' – which reflects how quickly owners will replace components once they show evidence of wear.

The sheer number of significant variables is testament to the difficulty of estimating durability for building stocks and other complex structures. But what is also important is the degree to which many variables are themselves influenced by cultural concepts of time. For example, investment in inspection and maintenance may have a long-term pay-off, and is probably closely linked to time preferences and societal attitudes towards long-term assets. The application of best practices in design and detailing is another example which involves trade-offs between short-term gains (new architectural fashion, new lower-cost techniques and materials lacking historical performance) and long-term insurance against failure by employing the precautionary principle and proven techniques. Even the original list of 3000 possible components available for construction will partly reflect the cultural norms and time preference. For example in North America, the roofing materials are typically 18-year asphalt shingles, with sheet metal rain gutters and troughs – materials that are too short-lived to be acceptable anywhere else in the world. Such timing norms are themselves complex subjects, reflecting differing attitudes towards craftsmanship, consumer products, home ownership, family and community.

The concept of 'service life' also reflects attitudes towards time: if structures are expected and designed to 'age gracefully', why replace components upon the first signs of wear? Perhaps most significant is the assumed lifetime for the structure as a whole – a value which defines the suitability of many component parts, especially the fixed and difficult to replace components like masonry, pipes and drainage systems. Stephan Allen and John Hinks have argued that the concept of an estimated lifetime for investment in new housing (typically 60 years in the UK), based upon an assumption of replacement at the expense of continual life-cycle maintenance, "is too disposal-oriented a supposition, and indicates a flawed consumerist philosophy in the light of ever-increasing environmental pressures." [ALLEN 95]

Technological obsolescence, and changing lifestyles and regulations, are factors that may be even more difficult to predict than component durability, and are potentially more significant when estimating the lifetime of structures. Not only do lifetimes appear to vary with cultural norms and local construction practices, but they also appear to vary with the pace of growth in urban systems, and the health of national economies. The average half-life for detached residential buildings in Japan built in the years 1961 to 1971 is just 29.9 years. [OHNO 05] Rising incomes in Japan – especially during the bubble in the 80s and 90s - have meant that many perfectly sound houses are quickly replaced with more affluent versions. Apparently the choice of wood or masonry construction has not influenced the lifetime of these dwelling. In Canada the current estimated service life of residential buildings is not much longer than in Japan. Building lifetimes are almost wholly determined by obsolescence, not deterioration in materials. [TRUSTY 04] In China, substandard concrete and rapid expansion of infrastructures appear to limit the service lifetime of new massive urban buildings to only 45 years, and of new conventional sized buildings to only 30 years. Such rapid turn-over implies not only a loss of continuity (the clock and mirror) but also a massive resource cost for replacement given the tremendous building boom now in progress. [YANG 05] In New Zealand the estimated current average service lifetime of the entire housing stock has been estimated at 90 years. [JOHNSTONE] However the building lifetimes have been shown to vary considerable in response to the increases and decreases in the size of the stock, and may also be affected by other non-design factors such as opportunities for infill housing in cities, refurbishment cycles, and national housing policy.

In Germany a study has been completed of the building survival functions in a typical township with stock dating back to the mid 17th century. [BRADLEY 06] This study is exceptional because it tracks survival for many age classifications of both residential and non-residential buildings with data collected over 330 years. Germany represents possibly an extreme situation for longevity of buildings due to the coincidence of many factors favouring extended lifetimes. For centuries the stock has been characterised by masonry construction, a demanding climate, a well-functioning and a well-maintained and well-designed urban structure. More recently Germany has experienced a strong economy relative to many other countries, a declining and aging population, and a policy environment that supports heritage preservation, and environmental conservation. Hence it is reasonable to assume that stock in German towns might survive as long or longer than most other locations. The research has revealed that survival functions appear to be very long, with the oldest classifications showing a half-life (50% loss) at >250 years. The rates of loss appear similar for all age classifications of residential buildings over the first century of their use. Annual demolition rates are very low for residential buildings, representing less than 0.5% of the total stock. Non-residential buildings have a demolition rate that is significantly higher, and their survival functions are lower.

Extrapolating lifetimes of contemporary buildings from the performance of older stock provides a time ring that may function for urban systems as a whole, especially if the survival rates are consistent and well documented over long time periods. However the rapid pace of change in cultural norms and in technology may create surprises, especially given the pace of growth for many urban regions, and the many forces that have been increasing time preference relative to past eras. Historically some buildings seem to have become 'eternal' structures, with lifetimes prolonged far beyond any economic rationale. A good example is the arena in Nimes, France, which has been in use continuously since AD 1, and which functions even today as a location for opera, trade exhibitions, and sporting events, despite encirclement by heavy traffic and commercial development. Throughout southern Europe there are roads, aqueducts, agora and other forms of infrastructure that have continued to function for millennia. Many small medieval towns, constructed in the 12^{th} and 13^{th} century, also tend to exhibit eternal functionality, (except where they succumb to automobile traffic). For example a majority of the 100+ towns established by the Dukes of Zaringen continue to thrive in modern times (e.g. Freiburg, Bern). Japan and Korea have examples of sacred buildings that are preserved indefinitely through period reconstruction.

At the opposite extreme are nomad societies which may have never built permanent structures and instead transport their built environment in the form of tents. Many fascinating intermediate solutions can be found. In the Greater Vancouver area, the Coast Salish aborigines that occupied the shorelines and streams for over 4000 years, would deconstruct the cedar plank longhouses, leaving only the structure, and carrying the valuable cladding materials with them during their seasonal migrations to fishing sites. A modern innovation is the ephemeral cardboard tubes created for victims of the Kobe earthquakes, designed by the Japanese architect Shigeru Ban. Exposition architecture has traditionally an ephemeral character - the Swiss pavilion at the EXPO Hanover by the architect Zumthor was realised by newly cut wooden planks, held together by vertical cables. At the end of the exposition they were deconstructed and used as construction elements in normal houses. [ZUMTHOR 06]

The benefits of ephemeral structures are self-evident, especially in a period of rapid growth and change. But the benefits of eternal buildings and towns are also substantial, especially in a period of rapid growth and change. Yet it is clear to any observer that the lifetime of modern structures – including churches, public buildings, arts and recreation facilities - is much less than the norm centuries ago. Why is eternal design no longer a common a feature of contemporary urban systems? Why is the time ring shrinking for building stocks and other features of urban landscapes?

The simple answer is already put forward: constructed elements reflect the time preference of the politico-economic system from which they emerged. The transition from mythic time to modern time is mirrored in the constructed environment, perhaps as it should be. Financial investors – the design clients - no longer feel a civic or religious obligation to emphasise in their designs a stable world view and a timeless mythology. Democracy has replaced the absolute power of the church and crown, and thus lasting monuments to glory are much less likely. Debt-driven economies have discounted the future, and thus long-term designs have become de facto uneconomic, even irrational. Time for construction is now a factor of production, and is optimised when before it was largely ignored. Buildings are built to standards of safety, and not to standards of craft. The building materials are transported long distances and are thus lighter and less robust. Transience of the urban workforce has turned buildings and their associated systems into commodities rather than a permanent family and community asset.

The increasing pace of change is a separate factor that makes long-term investments less likely due to the risk and complexity. Developers and designers lack both the incentives and the training to design buildings that can adapt and endure. Stewart Brand quotes statistics from North America that less than 10% of architects visit buildings after completion, which helps to explain why performance factors like durability and weathering are poorly understood. [BRAND 94] The designers and their clients tend to view buildings as a completed project once the commission or sale is finished, whereas in reality all elements of the constructed environment are works in progress. Mostafavi argues that even the inevitable and natural weathering is "a continuation of the building process", and should be seen as something that "adds to, rather than detracts from, architectural meaning." [MOSTAFAVI 93] He points out that architectural duration emphasises a past that is caught up in the present and anticipates the future by adding to the physical world, whereas architectural weathering reproduces the past in the present by subtraction. Brand imagines buildings that age gracefully, like an old pair of Levi jeans, gaining beauty and value with time by design. Can weathering and graceful aging become concepts that apply to built forms at the scale of town, landscape and urban region?

Regardless of design intent, the longer some items last, the longer becomes their estimated lifetime, since at some point age itself becomes a desirable feature. This odd reversal in expected lifetimes is illustrated conceptually in Figure 14, which shows the competing array of forces influencing expected longevity of buildings and associated systems. The actual shape of such curves will reflect cultural values and local scarcity for buildings of different age groupings. Thus a more strategic question is whether it is possible to influence lifetimes by targeting such forces as part of the design? For example can buildings adapt at lower cost and remain competitive for longer time periods? Or can buildings be designed to age gracefully without loss of functionality? If so, they can begin to serve additional functions over time, such as enhancing diversity, and providing communities with their clock and mirror.

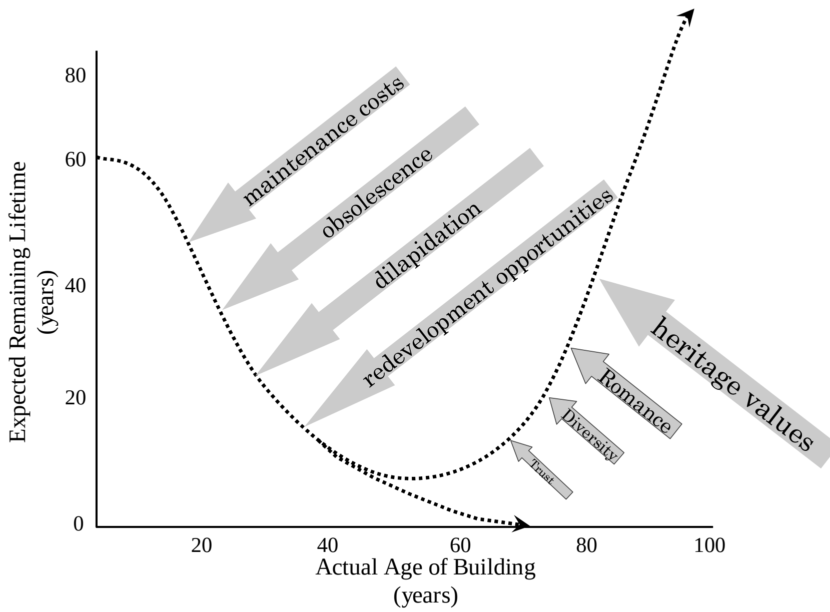


Figure 14 Although many forces conspire to kill buildings and urban infrastructure, at some point age itself increases the heritage values and creates a reversal in expected lifetime: the older the building, bridge, station or park, the more likely it will continue to survive. *(scale is notional)*

At the scale of urban systems the conservation of diverse forms in varying conditions may need to become a central objective. Hassler and Kohler argue that: "Through their historic diversity, quality and continuity the building stock constitute non-renewable resources….The better we understand how to administer and develop these investments, the stronger the urban environment will become." [HASSLER 02] They point out that a key aspect of administering the urban resource is the speed of transformation. The historical meaning may be lost when the speed of transformation is too high, or the physical elements are lost when they perish by dereliction because the speed of transformation is too low. Thus the challenge for urban design is to stay within a 'solution corridor'.

3.1.3 Time structures for urban design

Time structures are composed of grain (the size of units); periods and cycles; amplitude and rates of change. The time structure can also include some degree of regularity and stability, milestones, synchronization (of cycles) and a chronology that orients decision-makers to both past and future. Although these concepts provide a kind of language for discussing time and urban design, it would appear that little discussion has occurred. In contemporary design, the time structure is ad hoc and poorly defined. In practice, it can be defined as fine-grained, rapid, and near-future-oriented. [LYNCH 93]

Time horizons for design vary greatly depending upon the type of system, and the type of design decisions. It is also difficult to distinguish the difference between time frames for review – the 'refresh rates' and time horizons for considering design features and their effects and impacts. The typical refresh rates for an urban master plan or comprehensive plan is 5 to 10 years, and the time horizons for key factors (like population growth and demand for services) is approximately the same. Long range plans and growth management plans have time horizons of 10 to 20 years, and (until 2003) almost never more than 25 years. Some types of plans are forced to incorporate extended time horizons because of safety or replacement formulas for structural elements, or the economic amortization rates, but the extended time horizons have little or no impact of spatial planning or system design.

Other urban system plans and designs – parks, housing, transit, etc. - will have similar time horizons, although not necessarily synchronized to the master plan or any other schedule. Energy and water utilities tend to forecast demand on a 20-year horizon, refreshing the plans every 5 or 10 years, without synchronizing time horizons or aligning assumptions with any other regional plans. In the context of specific design decisions for urban infrastructure, the assumed time horizon is not always specified. Different horizons are adopted for different issues. For example engineering risk assessment may adopt a 50 or 100-year standard for the maximum flood or earthquake. Financial risk and amortization periods may range from 25 to 40 years. Mechanical equipment may be designed for 5 or 10 year lifetimes.

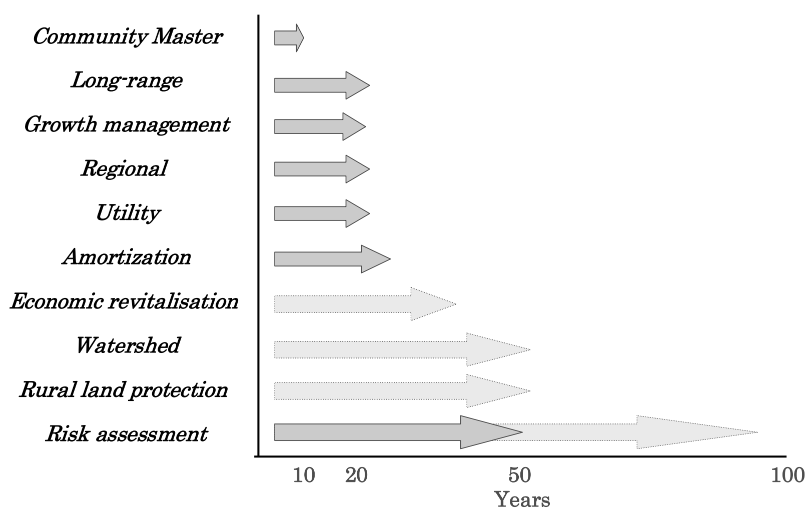


Figure 15 Approximate time scales for contemporary plans vary considerably, but most urban spatial planning, and systems design, is restricted to 5 to 20 years.

Figure 16 shows a typical range of 'best guess' renewal and replacement periods for key physical elements of urban systems. The disconnect between the time scales for turn-over of elements and the time horizon for design of elements is readily apparent.

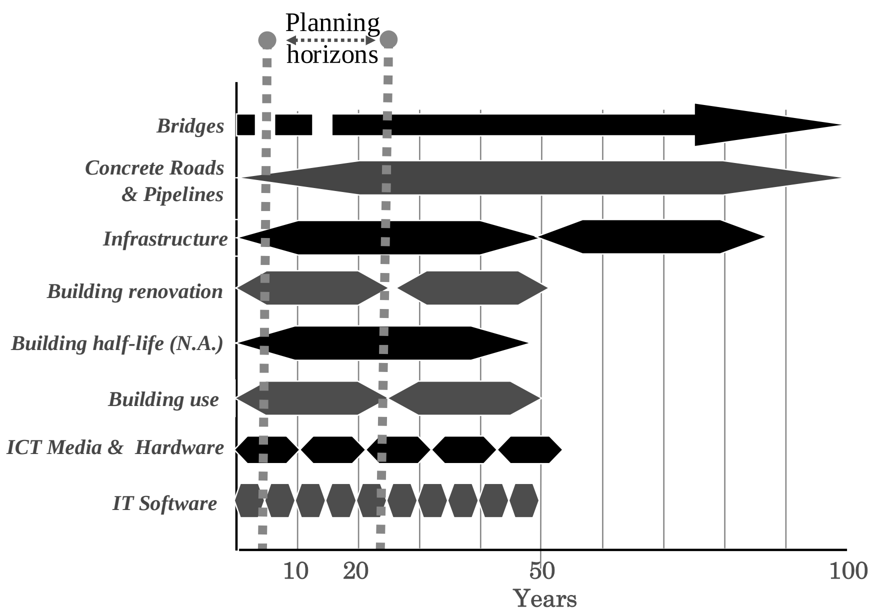


Figure 16 Lifetimes and renewal rates for urban systems are highly variable, and bear no relationship to the time horizons for urban master planning [adapted from KOHLER 04, redrawn and expanded by author]

Prior to this thesis research, only one example could be found of an urban region in modern times that had attempted to develop a long-term vision or design in excess of 25 years[3]. More to the point, the time horizons established for urban system design may carry little import, since they are typically used only for projecting build-out requirements at a single point in time. In other words, a 25 year horizon is translated into a fixed estimate of population growth or decline, and then this number is used to drive the targets for most of the infrastructure and building-related planning and design. Little or no consideration may be given to other factors that could influence infrastructure and building functionality, including long-term requirements for sustainability, a manageable pace of change, the degree of uncertainty in population growth projections, the impact of other (external) forces such as changes in technology or world view, the potential for surprise and the necessity for systems to adapt, innovate and learn.

[3] The lone exception is the *Meewasin Valley project: 100 year conceptual master plan* for South Saskatoon, Saskatchewan, prepared in 1979 by Raymond Moriyama Architects and Planners Toronto: Raymond Moriyama Architects and Planners.

A review of the seminal documents on urban sustainability, including the *Rio Declaration* for Agenda 21, the 2002 *Melbourne Principles for Sustainable Cities* [UNEP], the 1994 *Aalborg Charter* of the European Sustainable Cities and Towns Campaign, and the 1996 *Lisbon Action Plan*, [ICLEI] reveals that despite frequent references to long-term visions and outcomes there is no mention of long-term urban system design or even long-term horizons for urban planning processes. At least until 2003, no discernable effort has been made by cities or urban regions to rationalise and synchronize time structures across the urban systems, or to adjust time horizons to match either the expected lifetime of the physical elements, or the community goals for sustainability. In cases where community vision statements are specific, the time scale is usually one or two decades.

In broad terms then, it can be argued that most 'sustainable' urban planning does not actually consider the long-term consequences of decisions, nor is there any explicit or formal attempt to identify the 'critical' pathways for achieving long-term goals. Instead most progressive international efforts to promote sustainable, healthy cities place emphasis on empowering residents, and improving equity and accountability, through a more democratic, communicative planning process. The UN Sustainable Cities Program is a high profile example, operating in over 30 countries worldwide. It's thrust is on broad-based stakeholder involvement in city development strategies; participatory problem-solving through inclusive processes and pro-poor governance; mobilisation of local resource and commitment; capacity development and support for institutions; and urban planning and management, particularly in relation to Local Agenda 21 and the Habitat Declaration on Cities. No mention is given to long-term planning horizons, or even to the use of long-term visions as a way to support public process.

The absence of long-term planning and design may reflect the inevitable institutional momentum that tends to delay the uptake of new mind-sets and theory. Especially in the developing world, where issues of poverty reduction and equity have long dominated the agenda, it is understandable how extended time horizons might seem irrelevant or a luxury that somehow cannot be afforded. In the developed world, the explanations are less clear. It is possible that, as Peter Hall describes in his historical work on "Cities of Tomorrow", the planning profession is still biased against the systems thinking and "comprehensive" planning approaches that were popular in the 1970s and that have since been associated with a technocratic, top-down approach that fails to address the power imbalance and structural issues that frustrate so many efforts at progressive community planning. [HALL 2002] It is also possible that a fundamental conflict exists between the concept of long-term decision-making, and the contemporary theories of communicative and collaborative planning. Is it possible to embrace a long-term vision and pathway, while at the same time allowing for on-going feedback and learning? Are long-term frameworks pluralistic and open to change, or do they impose a false order or the complex self-organising city or region, and hold future residents hostage to goals and targets established by others? These questions can only be answered by observing how time concepts, and long-term horizons in particular, actually influence the design and decision-making process. This is the focus of Chapter 8 to 11.

3.2 What is the relationship between Spatial Scale and Time Scale?

The constructed environment is composed of many nested scales which interact to create the political, social, physical and economic systems that define towns and cities. In this thesis an emphasis is given to design of systems at the scale of an urban region. However the urban region is an amorphous concept that is difficult to define. Moreover it is not clear to what extent a regional scale approach is necessary to sustainable outcomes at more local scales. Thus it is necessary to explore how urban regions been defined historically, and how is that definition changing. And, in what ways might the regional scale offer advantages when introducing new time concepts in design? Is regional design a parallel exercise that complements design at other scales, or is it pre-eminent – providing the critical long-term context for all town and city planning?

3.2.1 The Region in Time

When large land areas are distinguished by certain unifying characteristics they are called regions. In physical geography, regions are defined according to their morphology and ecology. In political geography, regions are often purpose-defined, and vary depending upon the task at hand. Historically a political region might define a collection of human settlements bound together through functional ties: a common form of governance, a strong social identity, transportation corridors and other hard infrastructure, or a continuous exchange of labour and goods. In recent times the term 'region' has frequently been applied at the world scale to identify collections of nation states with similar functional ties.

An urban region is a special application of the regional concept, and was originally conceived of by economists and geographers as a way to describe the relationships between human settlements and their surrounding resource base. Figure 17 is a stylized version of Von Thünen's 1826 model of the 'city state', one of the first efforts at economic geography. Essentially the urban region is conceived as an efficient, solar-energy driven settlement. A central city is surrounded by a radial concentric pattern of primary and secondary producers - fruits and vegetables, woods, grains and fodder - distributed so as to optimize transportation costs in and out of the city. The city itself is the control centre, standing distinct and separate from its rural support base; the urban region is self-sufficient and distinct from the remainder of the prevailing world system.

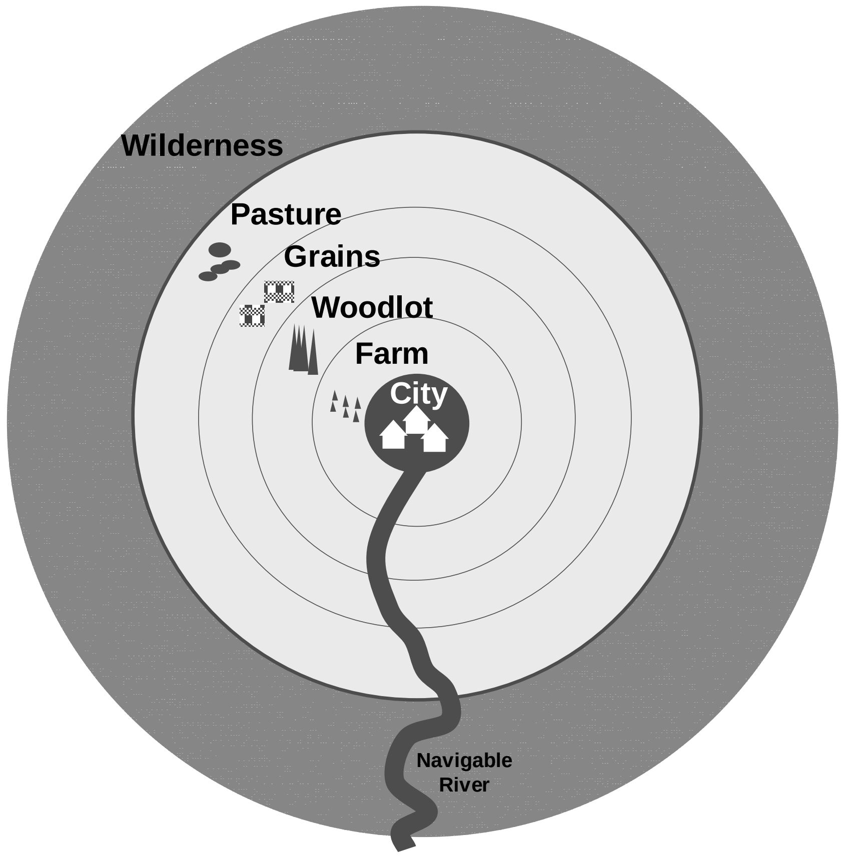


Figure 17 An idealised version of Von Thunen's 1826 City State, an urban region organised around rings of land use and economic activity

In reality the mid 19th century cities were already part of a rapidly increasing world system driven by fossil fuels, which liberated people from the limits of renewable biomass and made possible the rapid exchange of mass goods over long distances. From a morphological point of view these factors dissolved the dense centre of the urban models, and created the more distributed and networked forms now so common. The distinct separation of urban and rural disappeared and the concentric rings of solar-driven land uses were slowly replaced, first by the sprawling new coal cities (Manchester, Birmingham, the Ruhr Valley), and later by metropolitan areas and mega cities, with their vast networked hinterlands.

One of the pioneers of modern regional planning was Patrick Geddes who coined the term 'conurbation' for urban regions, and who authored the famous planning dictum 'survey before plan'. Geddes developed a theoretical base for urban planning based upon geographical conditions. He noted how areas are unified by problems of their development and by their resource base, and that "It takes the whole region to make the city." He argued that "a city is more than a place in space, it is a drama in time". Historical facts and trends are as important as geographical elements. [STALLEY 72]

A valley section by Geddes, shown in Figure 18, imagines a hypothetical region where the people and economy conform to the geography of place. Geddes' ideas were formative in the birth of the modern town planning movement, and influenced the evolution of the Garden City movement and the writings of Lewis Mumford – ideas that continue to frame discussions on urban design. [HALL 02]

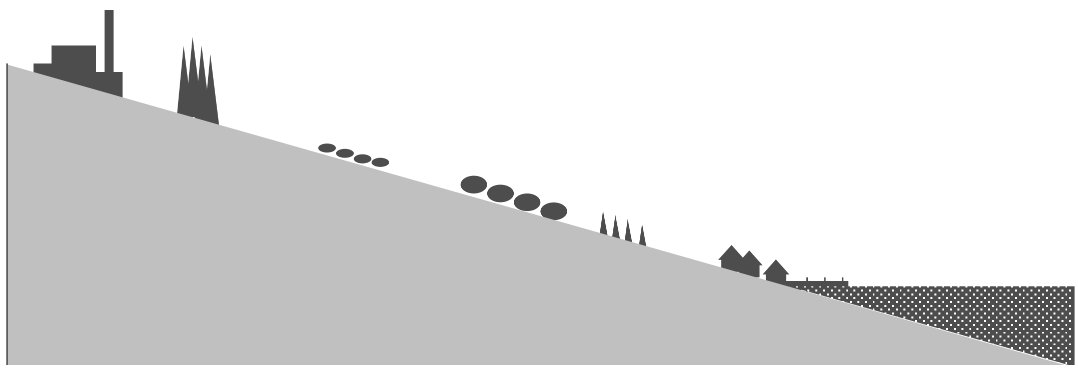


Figure 18 Patrick Geddes 1892 Valley Section integrates land use into the geography and is an example of the first attempts at regional urban planning theory

Since the 1920s onwards the 'region' has repeatedly been promoted a preferred spatial scale for design of urban systems. Mumford refined Geddes' theory of historical progression, in which regional planning is a further stage in the more specialised or isolated processes of agricultural, industrial and city planning. He defined regional planning as the "conscious direction and collective integration of all those activities which rest upon the use of the earth as site, as resource, as structure, as theatre." [MUMFORD 38]

The social and environmental costs of industrialisation was the driver behind the birth of utopian urban planning and a more integrated approach to regional design. In Ebenezer Howard's *Garden City* the territory around large cities was organised to provide a harmonious balance between urban and rural, a kind of technical fix to the horrendous socio-economic problems brought on by the industrial revolution. The Garden City lacked a solid theoretical basis. Although Geddes did meet with Howard on occasion, his theories of regional planning never became a basis for Garden City design. [CLAVEL 02] This may have been because Howard's Garden City was principally an effort to improve quality of life for working families, and focused primarily on financial innovations - new forms of land ownership that could capture the increased land value from city-building and preserve this wealth for the benefit of the working classes.

The spatial features of the Garden City were an effort to optimize economic functions with local amenities – linking cities together with transit to enable exchange – while retaining a scale and form that allowed for green and rural landscapes close to home. Howard's Metropolitan Region, shown in Figure 19, is the idealised image of an urbanised region. In the book *From Garden City to Green City* a number of authors examine the impact of Howard's ideas on modern urban design. [PARSONS 02] Robert Freestone points out that despite the very great differences between Howard's Garden City concept and the modern concept of eco-cities, a number of core ideas are still relevant including: the requirement for direct community action; the importance of practical civic infrastructure; the need for regional scale growth management and the combination of environmental amenities with social justice. In most respects however, the garden city remains a culturally and historically specific concept.

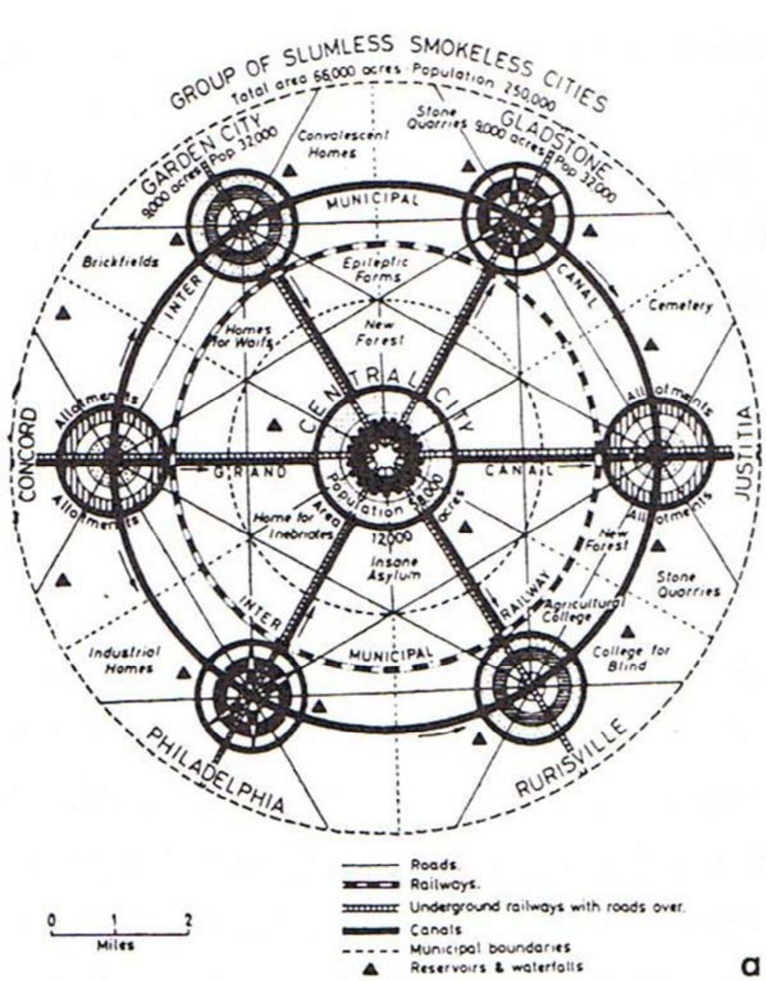


Figure 19 Ebenezer Howard proposed a Regional Network of Garden Cities in 1892, balancing economic functions with livability

Instead of Garden Cities, the industrial city has evolved over the past century into many disparate forms – the linear city or corridor region, the cluster city, the megalopolis. None of these forms however focus as Geddes did on designing the landscape first, and then fitting urban zones into the spaces between the natural functions. This applies also to the most recent wave of amalgamations and 'big city' metropolitan areas that now exist in many of the larger developed countries including Canada, USA, Australia, and New Zealand. While the amalgamated urban areas often include a majority of rural land, the rural is seen as an 'urban reserve' or 'green belt' retained for future growth; it does not represent a planning and design approach based on long-term dynamics or ecological principles.

Recently a new approach to regional scale design has been proposed under the title of bioregional planning. A bioregion can be defined as three subsystems: biophysical (i.e. nature, resources), constructed (i.e.

communities, agriculture, and transportation); and networks (i.e. economic, political, cultural). [THAYER 03] Building upon Geddes, bioregionalism begins with a continuous mappable geographic region based on similarities of topography, plan and animal life, culture and economy. The difficulty with bio-regionalism is that it does not offer any specific planning scale or tool, but rather a new paradigm - an "action-oriented movement based upon ecological principles". [TOMALTY 02]

In practice, most modern urban design is city-centric. The urban region – where one exists - is typically comprised of left-over pieces, or simply an amalgam of adjoining towns and cities circumscribed by natural barriers and borders. The political boundaries do not necessarily match the service territories of the utilities, or other key features of the constructed environment. And the boundaries change over time at differing rates. In some cases the boundaries become almost arbitrary, given the homogeneity of the landscape and the mobility of people and goods within an extended metropolitan area.

Further confusing the definition of region are the many different spatial dimensions required by each urban system and the environments that may be directly associated: watersheds, air sheds, market gardens, parks, and so on. Should the boundaries of urban regions be modified to encompass future extensions of in-the-ground utilities such as potable water, wastewater, gas, and district energy? Do boundaries need to vary if designers are to evaluate the effect of spatial factors - like proximity, density, form and diversity - on the performance of future development? Should consideration be given to the location of relay stations for broadband communications? to sub-stations for electricity?

In almost all cases the increasing connectivity between cities within a global economy is making urban centres into nodes on very large networks, a phenomenon that challenges the whole concept of the urban region as a contained space and place. Functional interconnections are growing at a grand scale, not only between industries but also the productive land base. Each urban area is now dependant upon a large and growing ecological footprint comprised of productive land and oceans in locations often far removed.

Even the commuting and travel distances for residents is continuing to expand, with unknown implications for what might ultimately constitute an region for the labour force. As Gesare Marchetti points out: "Ancient cities, be they Rome or Peking, did not become larger than a radius that could be transited by walking or riding on public transportation for one hour, and some spot checks indicate that the same is true today." [MARCHETTI 88] A pedestrian has an effective personal territory the size of a village – about 10 square kilometres. Once inside an automobile the person's territory expands to 1000 km2. Bullet trains and maglev trains increase the territory further, creating corridors linking massive cities into chains. The Shinkansen corridor in Japan, for example, which links Tokyo and Osaka, has for many years targeted a one hour transit time as a future goal, which effectively would create a single city of 70 million people. If such trends continue, Marchetti predicts that the ultimate 'transit territory' for the individual will become all major cities on the planet – any of which can be reached within one hour on a Mach 8 jumbo jet or equivalent. One planet, one urban region.

Given the many difficult questions, boundaries of regions are likely to remain fuzzy. Perhaps the challenge is to define a standardised and transparent method of adapting spatial dimensions to accommodate different performance issues. However if regional scale design is to accommodate new timing concepts, it is probably essential to move away from the city-centric model, and align regional boundaries where possible with the traditional approach that locates the urban systems within the slower and larger context of local ecologies, and rural or natural landscapes. Protection of ecological functions can be integrated with urban design, for a more balanced approach to the time rings.

Simin Davoudi, in her studies on urban spatial policy in the European context, has provided a historical perspective on the concepts now being used for urban spatial planning. [DAVOUDI 03] She distinguishes two prevailing models of inter-urban growth patterns: the monocentric city and the polycentric urban region. The monocentric model grew out of seminal work by the Chicago School in the 1920s. In their monocentric model, cities are centred on a dense urban commercial core, surrounded by concentric circles of residential area of decreasing density and land rent. Much later, during the 1960s, many additional models emerged to describe the possible spatial structures for stand-alone cities; for example Kevin Lynch in *The Future of Metropolis* evaluates and compares the star, ring, sheet, galaxy and core city patterns. [LYNCH 61] Not until the 1970s did it become clear that "cities of the future would become less nodal and would move towards the development of a poly nucleus urban structure." [DAVOUDI 03] Some debate still exists over the degree to which suburban centres and 'edge cities' reflect urban nodes rather than simply a textured form of urban dispersion. Also it is apparent that many cities are recentralising as young professionals choose to reduce commutes and enjoy a more urbane lifestyle. Nevertheless, a polycentric structure has become the common framework for modeling intra-urban structures. It is the long-range growth management framework for many growing and prosperous urban regions, including Greater Vancouver and Greater Sydney.

At the inter-urban scale the polycentric structure is just beginning to emerge as a new model for spatial planning. Polycentricity represents an alternative to the centre/periphery model of development, with potential advantages in terms of a more balanced and equitable form of economic growth within towns and cities across a region, and more diversity and lifestyle choice for residents. It is especially of interest within Europe, and elsewhere, as a possible strategy for achieving competitiveness in a global economy, without placing all eggs in the basket of a single massive city. EU policy, for example, has been giving increasing weight to the notion of socio-spatial polycentricity, as a means "to reconcile the social and economic claims for spatial development with the area's ecological and cultural functions and hence contribute to a sustainable, and balanced territorial development." [ESDP 1999]

The European Commission defines a PUR as "a region with two or more historically and politically separate cities without a clear hierarchical ranking in a reasonable proximity and with functional interconnection." Proximity is still commonly defined in terms first proposed by Patrick Geddes a century ago: a convenient one-hour one-way commuting time. Functional integration is usually defined using labour market flow (numbers of commuters) although some researchers have proposed including non-work trips and the flow of resources and information. According to Simin Davoudi, a PUR is a spatial distribution that looks something like a bunch of grapes. Figure 20 shows examples of both the monocentric and polycentric urban form.

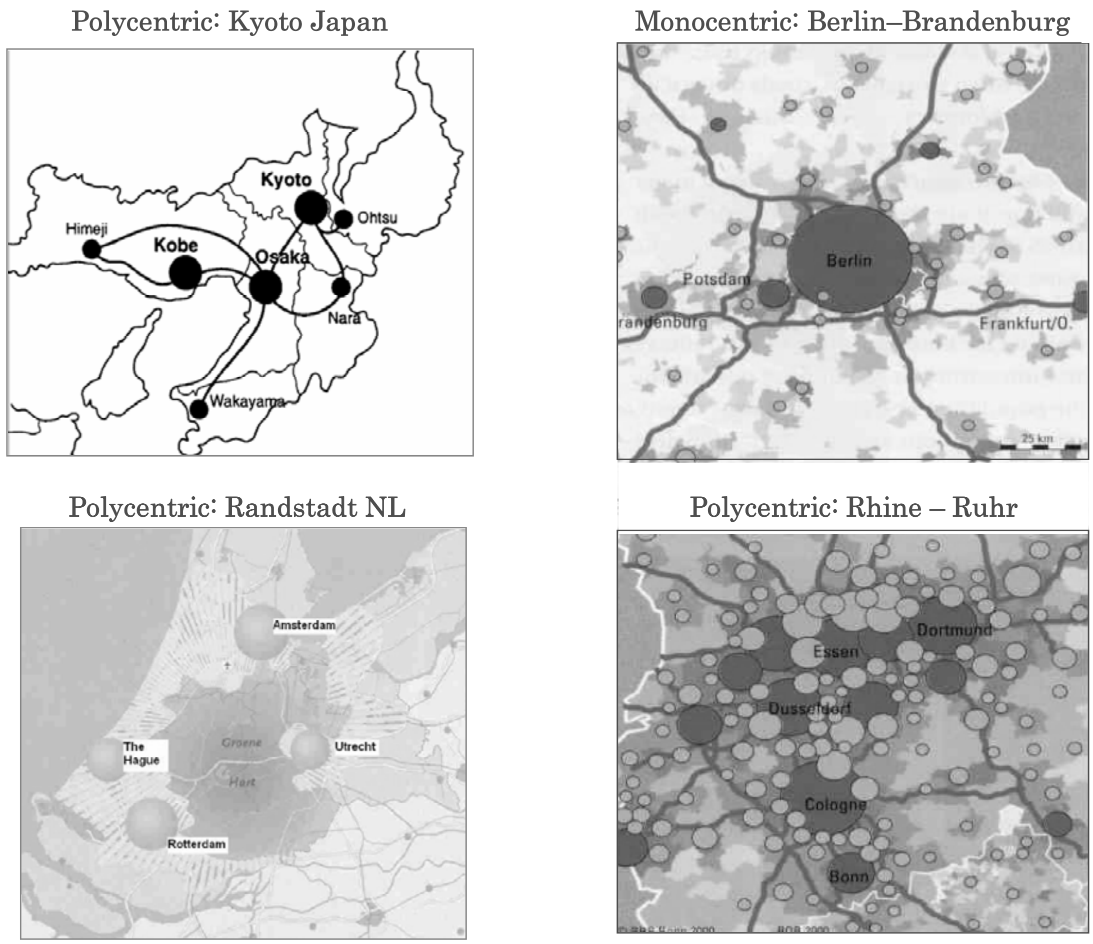


Figure 20 Polycentric urban regions appear to offer a more balanced development model, although the complex and unique nature of such interrelationships, and recent rapid changes in technology and lifestyle choices, may when compared to the centre/periphery pattern of monocentric regions [extracted from DAVOUDI 06]

Davoudi points out that part of the difficulty with planning development within a PUR is the lack of formal administrative structures. Often the various settlements within the region are unwilling to forfeit any control. Moreover the inclusion of regional infrastructure systems and adjoining rural areas means that many additional players and jurisdictions must cooperate. For these reasons regional-scale planning and design is galvanizing a growing number of flexible multi-agency partnerships at the inter municipal level, which include public, private and voluntary sectors. It is possible that regional scale design may ultimately be dependant upon the creation and effectiveness of such collaborative decision-making models. The principle weaknesses with such regional initiatives is the lack of resources for facilitating such collaborative process, the tenuous nature of commitment by participants, and a general lack of experience by all parties in regional-scale and collaborative activity. [DAVOUDI 06]

Davoudi is cautious about current policies that embrace the PUR as a model for better spatial planning policy in Europe. She argues that very limited empirical evidence exists to suggest that the PUR is more effective than other models as a means for achieving a balance between social goals and improved economic competitiveness. Nor is there evidence that PURs can be created as a result of policy initiatives. She argues that there is still considerable confusion over the interpretation of such terms as proximity and functional integration. Functional integration for example, requires complementarities between a unique collection of local businesses and services in each centre; synergies of this complexity are not likely to emerge from a one-size-fits-all spatial planning policy. More importantly from the perspective of this thesis, she points out that the "interplay of globalisation processes with place-specific qualities that are developed historically and culturally over a long period of time is the determining factor in the economic fortunes of the cities." [DAVOUDI 03]

This criticism may cut to the core problem of attempting to develop urban system design without a more sophisticated approach to balancing the very different time constants for the urban elements in question. Global markets are not much different from local markets in their rate of change – changing rapidly with fashion and cycles of innovation. Thus global competitiveness - so central to the new urban planning initiatives – is fundamentally short-term, an inner time ring. It is difficult to understand how such strategies can provide the impetus for restructuring slow moving elements such as regional land use patterns, transportation corridors, cultural identities, or the critical environmental resources within the region. Did the European cities of the late middle ages, that now have become so prosperous in Europe, achieve their success because they chose the right industry cluster?

Ideally both the boundaries and structure of an urban region should firstly reflect the functions of the region over the long-term, and then explore how best to adjust or adapt the structure to the changing pattern of global economics. From this perspective, it may be insightful to compare and contrast locations where regional planning has been institutionalised and has achieved some success over the longer-term. These exceptions tend to fall into three very different categories: (1) watershed planning - for example the Tennessee Valley Authority in the USA (1933) or the Fraser Basin Council in Canada; (2) planning for protection of rural land resources and containment of urban sprawl – for example British Columbia's Agricultural Land Reserve and Islands Trust (1974); and (3) economic development or revitalization of resource dependant economies – for example the Ruhr valley redevelopment process (1990-2000) in Europe. Without more extensive research it is difficult to use such case studies to clarify questions about: How to define flexible boundaries? How to reconcile short-term and long-term functional connections? How to bring together the many different players and visions as part of an effective collaborative process?

Transdisciplinary Methods for Regional Scale Design

A particularly well documented case study of urban regional design is the long-term plan prepared by Peter Baccini et al for the Swiss Lowlands, an area similar in size to Greater Vancouver and the Fraser Valley of British Columbia, but with twice the population density. [Baccini 02] Baccini and his colleagues began with the assumption that changes to urban form, in combination with changes in the relationships between urban centres and the surrounding environment, have been so significant over the past century that new models and methods are essential for effective resource management and planning. They argue that sustainability implies we reconstruct urban systems as whole regions that are, once again, primarily driven by solar energy and it's renewable by-products. This approach is similar to long-term ecological design philosophies where cities are embedded within the surrounding ecology: "The living city is not an island: its metabolism is interlinked to surrounding ecosystems and its people and culture networked to other viable urban cells to form a living and developing tissue, a net primary producer, not a parasitic system." [India-Goa 2100 Team 03]

Baccini's case study addressed the characteristics of the methodological tools needed for long-term reconstruction of the urban region. He adopts a 'transdisciplinary' approach in which tools and concepts from different disciplines are shared in common by designers, and where local knowledge is incorporated in the analysis and decision-making. The Baccini transdisciplinary approach to design of urban regions is called the Netzstadt Model, and is illustrated in Figure 21.

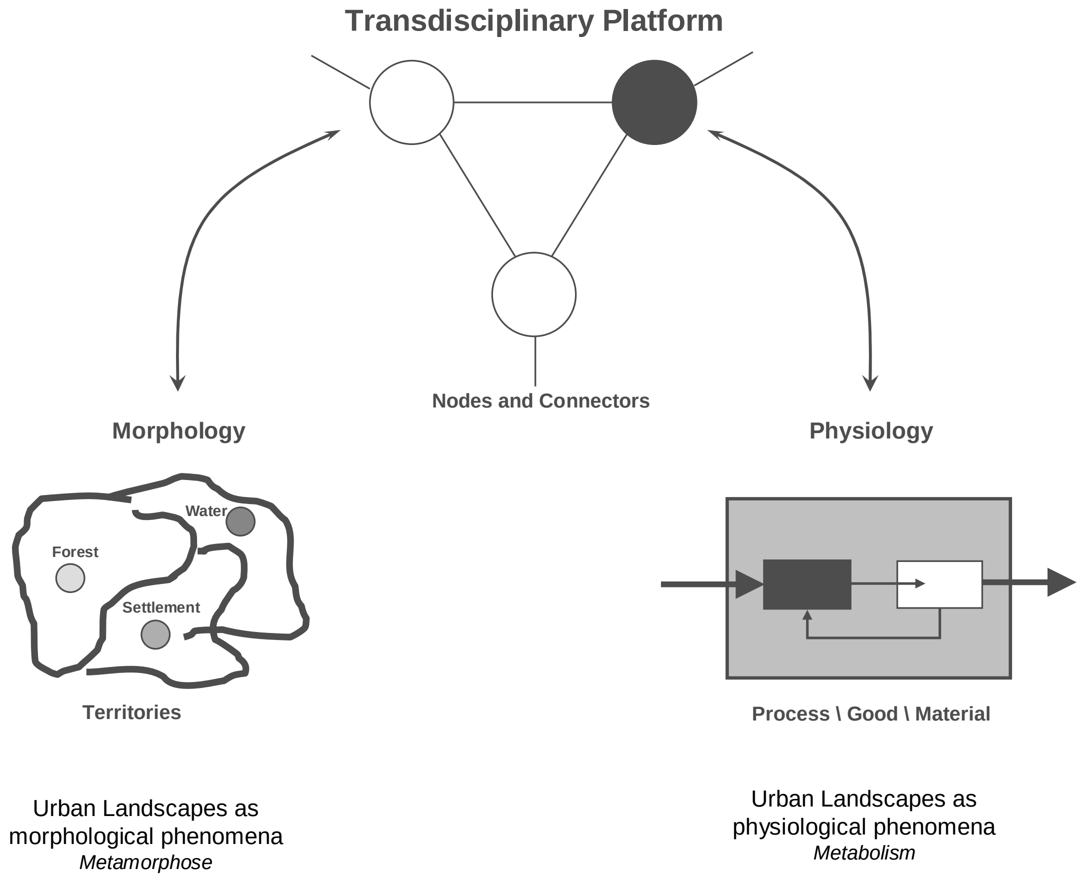


Figure 21 The Netzstadt Model combines spatial planning with physical flows in an effort to achieve whole system design solutions [BACCINI 02, redrawn by author]

The Netzstadt model centres on a purpose-defined open system network of nodes and connectors. Nodes are high density sites for people, goods or information. Connections are physical relationships expressed as flows of people, goods and information. The exact composition of the nodes and connectors is something that is determined as part of a multi-disciplinary consensus process, as groups identify what is important to the creation of the morphological and physiological subsystems. The morphological subsystem may include all the land uses, and the natural and constructed environments from which the territory (or urban region) is composed. The physiological system will include flows of energy, material and water that are deemed relevant to the goals of the design task.

The Netzstadt Model combines a metabolic model with a spatial and physical plan, and is an attempt to align both analysis and design. The arrangements and quantities of flows, and their interdependencies, are first defined at the regional scale, and then at the community and local scale.

Networks that are analysed or designed at a fine scale can be lumped together as nodes at the macro scale.

The Netzstadt Model evaluated a variety of development scenarios over a 50-year time horizon, using a set of indicators including: density, diversification, identification, flexibility, self-sufficiency and resource efficiency [Baccini 1998]. Various case studies have been described as applications of such a model, each straddling the physiological and morphological perspectives. An energy and gravel case study focused on density and resource efficiency; an analysis of a 'forest city' worked mainly with diversity, flexibility and self-sufficiency; a money-flux analysis focused on resource efficiency (as money) and flexibility.

The comparison of flows for multiple design options was used to identify priorities for urban system design in the Swiss Lowlands. Two key conclusions are worth mentioning: the energy demand for building maintenance and operations is the most significant challenge for sustainable reconstruction of the region, since materials are relatively abundant and can be 'sacrificed' if necessary to energy resource efficiency. The second conclusion is that successful energy policy must be synchronized with long-term settlement planning, since the energy flows are significantly influenced by the morphology (urban landscape) in the region, and the long-term money flows are significantly influenced by both the morphology and the physiology of the region.

Baccini's methods and case studies suggests that the long view is integral to regional urban system design. His analysis of morphological factors included the precise configurations between forested areas (for biomass) and settlement demand for energy and materials – a design element that can only be considered within the context of long-term natural cycles. His preferred scenario - reconstructing many buildings incrementally across the regions - is a design choice that, once again, can only be practically considered through time extensions. This same realisation was even more apparent in yet another case study of materials flux analysis in the Swiss Lowlands [MULLER 2002]. The authors conclude by stating "As the most effective long-term ways to manage carbon and energy require restructuring the built environment, these ideas must be integrated into urban planning projections, with a time horizon of at least 50 years." If Baccini and his colleagues are correct, possibly the greatest technical challenge for sustainable urban system design is combining a long-term systems perspective with a more consensus-based and transdisciplinary process of design.

The advantage of the regional scale can be restated in terms of the systems perspective proposed by Baccini and others. By focusing on the regional system as a whole – natural and constructed - the designers and policy-makers can work together without confusion. Jamshid Gharajedaghi, in his book on *Systems thinking: Managing Chaos and Complexity*, argues that "Contrary to widely held belief, the popular notion of a multidisciplinary approach is not a systems approach. The ability to synthesize separate findings into a coherent whole seems far more critical than the ability to generate information from different perspectives." Systems thinking is the art of simplifying complexity, seeing through chaos, managing interdependency, and understanding choice. Garajedaghi argues that we see the world as increasingly more complex and chaotic precisely because we use inadequate concepts to explain it. "Once we understand something, we no longer see it as chaotic or complex." [GHAR 06] It is only at the regional scale where it may be both possible and practical to develop a systems model of urban flows that includes the key elements of the natural environment, and that can be modeled and designed over the long-term. Smaller boundaries are likely to loose key system dynamics, larger boundaries probably lie outside the aegis of the local designers and collaboratives.

Although regional scale may improve systems thinking in urban design, it does not address the myriad of flows and dependencies at inter-regional, national and global scale. As Anthony Giddens points out, the global trade exchanges now amount to over 1 trillion dollars daily, and is symptomatic of a massive cultural shift that is bringing all of the world's regions closer together. [GIDDENS 2002] This 'run-away' world may be creating a degree of complexity and apparent chaos that cannot be simplified by systems thinking.

Time as a Feature of the Landscape

When time scales are applied at the scale of an urban region, it becomes possible to imagine a timescape, where the pace of living and work varies to reflect cultural diversity and resource availability. Kevin Lynch argues that more diversity is needed in the 'timescape', so that some locations can choose to move at a slower rate of change, while others become more future-oriented. [LYNCH 93] A similar argument is made in the 100-year *Grounds for Change* design for Northern Netherlands, where locations lacking in energy resources have been reserved for people who prefer slower and quieter rural lifestyles, with greater self-reliance. [ROGGEMA 06] A timing model of urban systems across the region might permit such diversity to arise through design. Presumably a timing model could also allow for better use of all spaces and facilities during the day and night, and across changing seasons.

Timing models for landscapes are also needed to assist emerging groups such as the 'slow cities' movement with the difficult task of time-based metrics and design tools. The *Slow Cities Charter*, first developed by a few dozen cities in Italy in 1999, is now being adopted and expanded by towns and cities worldwide. The slower pace promoted by their philosophy is largely achieved by extending time horizons and focusing on the time rings of nature and place. The first three items of the charter read: "(1) implement an environmental policy designed to maintain and develop the characteristics of their surrounding area and urban fabric, placing the onus on recovery and reuse techniques; (2) implement an infrastructural policy which is functional for the improvement, not the occupation, of the land; and (3) promote the use of technologies to improve the quality of the environment and the urban fabric."[4] The slow cities, in concert with slow food and slow planet initiatives, may represent proto-design philosophy that incorporates new timing concepts. Fuad-Luke argues that this is the conceptual birth of a 'design for sustainability' paradigm that attempts to "balance socio-cultural and individual needs with the well-being of the environment." [FUAD 02]

3.3 The Essentials

The constructed environment orients the community within time scales that stretch for many generations. By bringing together past, present and future in a "temporal collage" it reflects and reinforces world views and helps to inculcate a sense of community identity. The constructed environment serves to both direct and regulate change in society. It functions as both a clock and mirror.

Globalisation, cheap energy and rapid technological change, population growth and urbanisation are some of the forces that may impede the ability of constructed environments to function as a clock. Many urban regions today are too new to have heritage value, or they have erased their temporal collage through urban renewal. Trends in modernism in architecture confuse the 'timescape' by mixing up chronologies and by adopting an international theme-park of styles that are largely unconnected with the local conditions past or present, and reinforce views of the future as global, alienated from history and geography, and thus unsustainable.

Time structures and spatial scales used in urban design today tend to be fine-grained and ad hoc, and are unable to address the slow-moving, and yet highly influential elements of urban systems, or to achieve balance across time rings. Heritage preservation may be successful at the scale of individual buildings, but often fails to capture the relationships between

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[4] See http://www.ecocitycleveland.org/ecologicaldesign/whatcities/slow_charter.html July 06; also

groups of buildings – open space and townscapes- or other aspects of the past at regional scale.

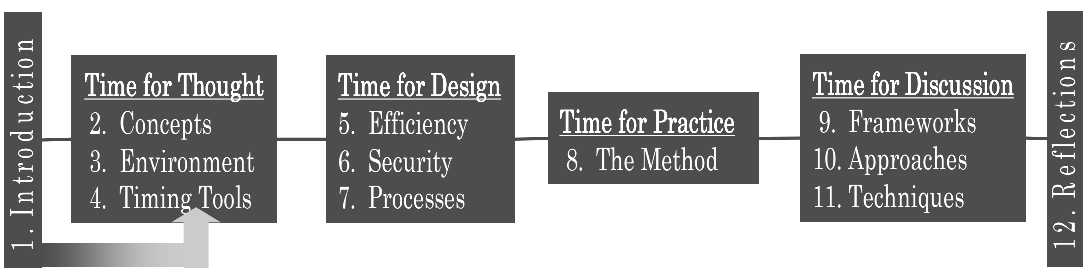
The design professions appear poorly equipped to address the inevitable change processes: weathering, adaptation, renewal. Planning horizons and refresh rates bear almost no resemblance to the actual lifetime of urban systems. Longer-lasting elements are not designed with respect to models of the future conditions in which they must operate except for population growth. Current time concepts do not help designers cope with the high levels of uncertainty over the projected lifetimes.

Part of the solution may be an approach that combines community participation and goal-setting with long-term integrated spatial and physical modeling. The regional scale appears particularly well suited to this type of activity, although considerable flexibility may be required in establishing boundaries and in the types of structural models used for defining the spatial distribution of urban nodes within the region. Ideally an urban regional approach allows for designers to address the longer cycles of the natural environment upon which towns and cites are dependant. Transdisciplinary approaches may be required in order to integrate the various urban systems over the long-term scenarios. Regional scale may require collaborative models of governance. Regional scales appear to make possible a systems perspective that can reduce complexity and allow designers to incorporate within their designs slow-moving elements and natural cycles.

4 What Tools and Methods Apply Time Concepts to Urban System Design?

Long-term sustainable urban system design depends very much upon the on the ability of designers and decision-makers to model, communicate and evaluate their design choices with respect to multiple, plausible views of the future. [LEMPERT 03] It is here where the design process encounters the greatest level of uncertainty and complexity. Many researchers and practitioners have argued that Decision Support Systems (DSS) may be essential to manage such a complex decision-making process efficiently. Computer-based models in particular allow for much more convenient and powerful scenario analysis than is otherwise possible, and at some point in the future it is reasonable to assume such tools will become universal. However the chequered history of computerised urban design tools emphasises the difficulties. In reality very few tools are used at present and expectations may need to be tempered.

Can DSS cope with time extensions, and approach urban system design from the perspective of time rings and time cycles? Are methods and tools sufficiently interdisciplinary, scalable and flexible to satisfy the exigencies of daily design practice? This chapter will explore the universe of DSS and the potential for introducing new time concepts through timing tools.



4.1 What tools might be adapted to Time Extensions?

At the theoretical level, it is possible to image that a variety of DSS tools can be customized for different users and purposes. A full slate of DSS possibilities is illustrated in Figure 22, a list that incorporates tools identified in this thesis, and also tools identified by Gregory Kersten in his book on *Decision Support for Sustainable Development : A Resource Book of Methods and Applications*. [KERSTEN 2000] Some of these tools employ models that can assist in shaping the future towards a desired end of sustainability. Thus one way to describe the use of such future-oriented tools could be 'syntropic design'. It is these tools that bear scrutiny in this chapter.

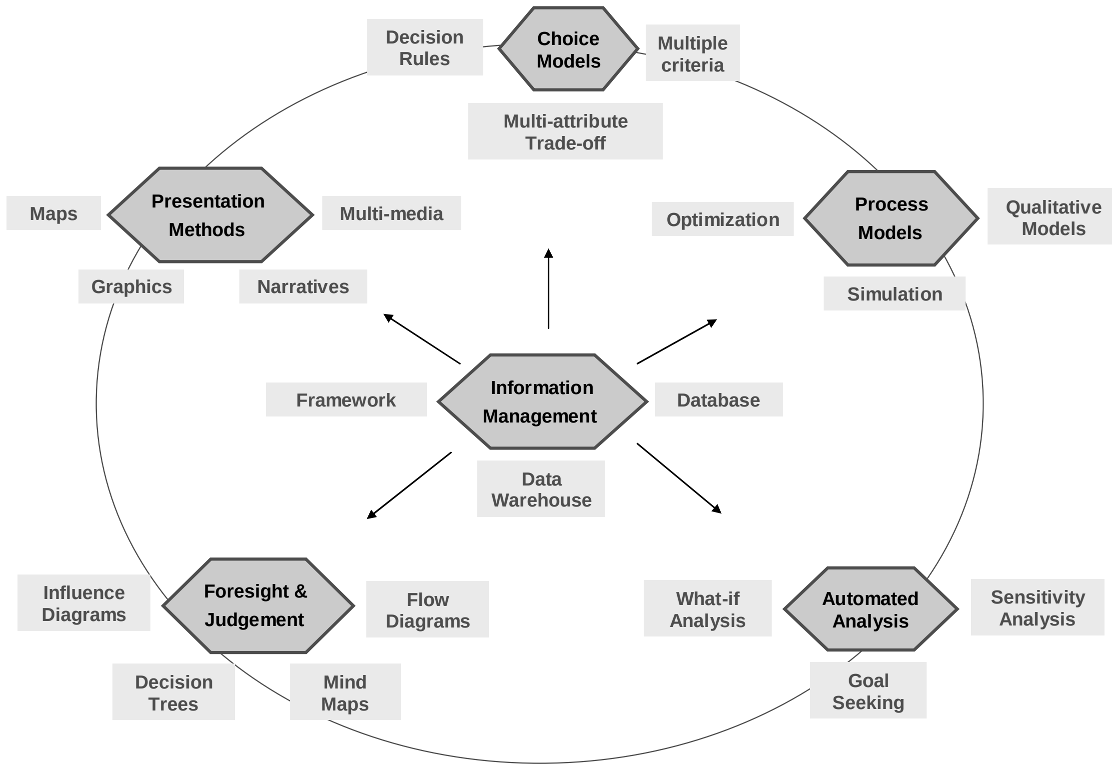


Figure 22 The universe of Decision Support Systems (DSS) from which it may be possible to derive timing tools for 'syntropic' design

Originating in the 1950s, computerized models were promoted as systematic devices able to simulate urban development under alternative planning scenarios. The use of models in the planning process was very much consistent with the rational view of the time, which assumed that comprehensive, rational, and neutral methods could be used to find the most optimal solutions to urban problems. [HALL 88]

Initially large mainframes were used to develop urban-scale system models [KLOSTERMAN 94]. The models dealt with primary issues for urban planners: allocating land uses, transportation systems, and urban growth. In the 1960s the emerging methods of linear programming, and operations research led to substantial investments to develop urban system models for several cities. By the 1970s, this early modeling activity ended largely in failure since few models were operational and even fewer achieved their intended objectives. [KLOSTERMAN 94]

It was in this context that Douglas Lee wrote his influential essay, "Requiem for large-scale models," in which he critiqued urban system models of his day and offered recommendations for future modeling efforts [LEE 73]. In a follow-up article written almost twenty years later, [LEE 94] he condensed his original critique to three main lines of attack. First, model design often exemplified the metaphoric "black box" – neither transparent nor understandable – as such, these models were largely impractical to the planning profession. Second, models often strived to be too general and all-inclusive in their purpose, as a result largely failing to account for numerous complexities governing real-world behaviour. Third, models were often developed as supportive tools for a particular planning approach, and thus failed to remain practical as planning evolved. Lee recommended that future modeling efforts favour transparent, simple models, based on strong theoretical foundations and objective information, carefully matched to the users needs.

Hall also describes the failure of the rational approach, along with emerging systems design models in the 1970s. With its formal hierarchic, sectoral organisations and procedures, it failed to cope with non-standard issues and to capture the knowledge and opinions of experts outside the core group. It also became suspect as a way to rationalise existing power structures, especially in an era of rising community participation and empowerment. [HALL 88]

Advancements in modeling theory, model design, and information technology have since revolutionized the capability of tools. Lee's most serious claim remains relevant today: models developed to dovetail with one planning philosophy are often ineffective in the context of another. In particular the rationalist approach does not necessarily fit well with the political process, and thus some hybrid approach may be needed to allow for changes to key assumptions so that they better reflect the principles, goals and norms of the decision makers and stakeholders. The integration of political and technical methods will be addressed further in Chapter 7.

In their book on *Ways to Study and Research – Urban, Architectural and Technical Design*, de Jong et. al. present a very broad array of methods and tools for research and modeling. They create a typology of models for architectural research, including verbal, mathematical, visualisation, empirical, forecasting and problem spotting. In their section on forecasting they review common tools such as curve fitting, forecasting external variables and scenario development. Scenario development is given special attention, as a tool that is primarily suited for stimulating creative thinking among experts, rather than as a forecasting method. Figure 23 illustrates the range of foresight tools and their relationship to the key design forces.

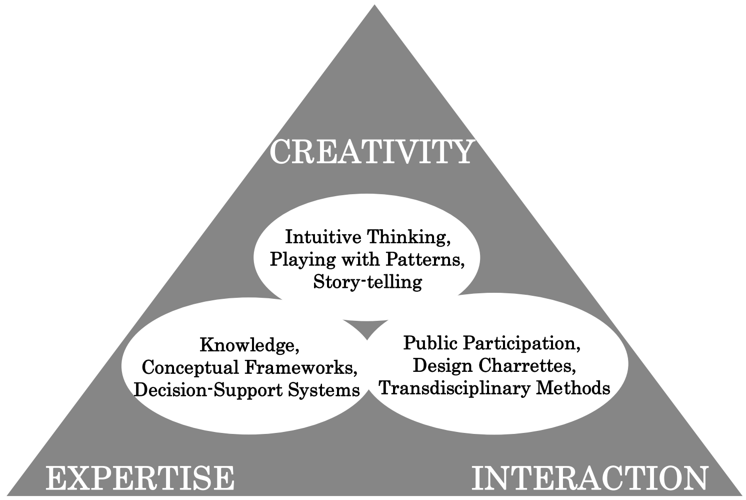


Figure 23 A range of DSS organised according to their ability to stimulate three design forces [adapted from triangle in DE JONG 03]

In their book on *Shaping the Next One Hundred Years – New Methods for Quantitative, Long-term Policy Analysis*, Lempert and the RAND team conclude that the solution to long-term policy analysis is not any specific type of tool but rather a combination of tools drawn from a range of methods. This conclusion probably holds true for urban system design; but which tools are most appropriate and how can they be adapted?

4.1.1 Narratives

Narratives are an age-old technique for engaging people in imaginative exercises for envisioning the future. At their core, narratives are memorable stories about what has occurred, and what may come. They have served many purposes. Most future narratives are created with the aim of commenting on and shaping the present, rather than supplying an accurate road map for what is to come. In the context of public policy and design "the principal value of narratives is that they provide a tool to help people confront the long-term future and frame what appear reasonable courses of action by imagining what it may be like to live there." [LEMPERT 03] Narratives can be utopian, like Plato's Republic (360 BC), or alarmist, like Rachel Carson's Silent Spring (1962).

Patterns, or 'lessons from history' help to ground narrative predictions. For example a narrative may be based on a specific period in history from which parallels can be drawn to contemporary or future times; or a narrative can be based on repeating historical cycles, which are superimposed onto current forces and trends. For example, globalisation, global warming, urbanisation, rapid change and environmental stress are all phenomena that have transformed urban regions many times, and yet unlike many other civilizations we are now in a position to learn from past experience. [DIAMOND 06]

Ancient civilizations all recognized archetypal patterns such as unity and peace, division and war, rehabilitation and growth. In modern times many philosophers have postulated much more specific patterns and combinations of cycles. For example Marx and Toynbee, Spengler and Sorokin, all described history as an unfolding of an inherent pattern. The contradictions between such views, and their almost universal failure to foresee critical aspects of the contemporary world, may explain the current lack of faith placed in long-term narratives as a policy and design tool. [LEMPERT 03]

A more successful application of narratives in urban design is as a tool to animate and stimulate public interest in alternative visions. For example a narrative may describe a 'day in the life' of a person living in different types of neighbourhood designs. This approach can be especially effective when supported by visual artists who, in broad brush strokes, can illustrate the story and help to bring it alive as a visionary tool. A 'community atlas' is a related technique that uses locally-designed maps, plans and visuals to communicate aspects of the future for an entire region.

Some community atlases are becoming web-based and animated – a form of digital narrative. All kinds of stories can be designed for web-access, hyper-linked to databases and commentaries, animated with videos, and augmented over time, and generally used to inform and stimulate designers and other participants. Both digital narratives and atlases are relatively new, but even a cursory look at some of these products is likely to convey their tremendous potential as an educational and visioning tool.[5] The sudden widespread use of GOOGLE EARTH may be a harbinger of the coming era for popularized digital design tools. The DIGITAL EARTH initiative, initiated by Al Gore in 1998, is now hosting conferences annually, with many researchers cooperating to build a common platform for both conveying information through geographical interface, and for developing predictive capacity and sustainability models that can be visually displayed in popular formats.[6]

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[5] For a good example of a printed community atlas see: *Stó:lÇ - Coast Salish Historical Atlas*. (2001) Carlson, Keith (ed.). Seattle: University of Washington Press, Vancouver: Douglas & McIntyre Press, and Chilliwack: Stó:lÇ Heritage Trust,.
For a good example of a digital atlas see:

[6] See www.digitalearth.gov and www.digitalearth06.org.nz

4.1.2 Foresight and Expert Judgement

A number of techniques have been developed specifically to engage large groups of experts in envisioning the long-term future and developing appropriate design strategies. The first formal tool was the 'Delphi' technique, developed by RAND researchers in the 1950s. Through anonymous responses to an iterative series of key questions, experts are encouraged to address contradictions, and to work towards a consensus on the future probabilities. The Delphi technique can be insightful, but it has not been particularly successful as a predictive method. Lempert and the RAND team attribute this problem to the fact that many of the topics of interest are simply unpredictable, no matter how much is known about them. Another problem may be that the experts' interaction is not sufficient in itself to address differences in paradigms and fundamental assumptions. [LEMPERT 03]

Transdisciplinary research methods, as used by Baccini in his work on the Swiss Lowlands, represent an alternative approach to engaging experts in complex long-term project design. A host of other visioning and exploring techniques can also be used to bring groups of experts together as part of 'think-tanks' or workshops on future urban issues. Such techniques can be referred to as 'creativity tools', and include trial and error, brainstorming, morphological analysis, method of focal objects and lateral thinking. The most systematic effort at developing a suite of such creativity tools may be TRIZ – a theory of inventive problem solving that was initiated by Genrich Altshuller in Russia in 1946. TRIZ has since evolved into a methodology, tool set, knowledge base, and model-based technology for generating innovative ideas. Although there may not yet be applications of TRIZ to urban system design specifically, it is a method well suited to interdisciplinary work and engineering problems. Possibly the greatest contribution that TRIZ offers is its broad scope. The method has identified 40 'principles of invention' - segmentation, universality, feedback, and so on - which are illustrated with examples and which can be directly applied as heuristics to help design teams overcome the contradictions that underlie technical problems. Although TRIZ has received praise from a number of inventors and may be a useful as a reference tool, it lacks a proven track record as a tool capable of generating any significant solutions.

In the field of urban planning and design, communicative planning has been promoted as a field-tested method for engaging stakeholders and experts in a more dynamic, open-ended enquiry. An example is the Sustainable Cities Program's *European Awareness Scenario*. [BILDERBEEK 94] Communicative planning uses techniques such as the 'strategic choice method' and 'reflexive action', to bring experts together into informal or temporal forums where they can engage with stakeholders, and learn by doing. Knut Stromberg argues that an important element of such methods is the problem-structuring process. [STROMBERG 04] Essentially the 'framing structure' is flexible and can be re-framed to reflect changes in basic premises or other types of learning within the group. The reframing of problems creates a process referred to as 'double-loop learning' – something that was first proposed in the 60s by Donald Schon in his proposals for a 'learning society'. The argument behind double-loop learning is that institutions themselves are often part of the problem, and thus changes to mandates and operating paradigms must be included within the scope of the community options. [SCHON 71]

Engaging experts in highly interactive and community-based exercises may be a critical element to long-term problem-solving. However according to Stromberg, two difficulties arise. Firstly the stakeholders may be participating because of vested interests, which tend to disappear when time horizons are extended. Thus the stakeholders themselves loose interest and disappear, especially as communicative processes tend to take up a lot of time. Secondly the issues are complex and can require that participants digest a large quantity of information, especially given the open frame. Thus the process can be intellectually exhausting. For both these reasons the success of communicative planning may depend upon tools that promote a 'systems approach' and from more intense, time-limited exercises, such as design charettes.

4.1.3 Design Charrettes

A design charrette is another tool for generating foresight and expert judgement, but with a much greater focus on the process of interaction, and the visualisation of alternatives. "Charrette" is a French word meaning wagon. "En charrette" was a term used by architecture students at the old Ecôle des Beaux Arts in Paris to mean "to draw at the last moment". Working feverishly until the last possible minute, students would sometimes run after and jump onto the wagon that had been dispatched by the professor to the student quarter and continue to draw. In recent years, the term has come to describe a design workshop in which designers work intensively on a problem and present their findings in a public forum. In America the method is promoted by the National Charrette Institute (NCI)[7] and in Canada by Canada Mortgage and Housing Corporation [CMHC 04].

Over the past 10 years charrettes have become a common tool for facilitating innovative building and neighbourhood designs. The NCI, in their Charrette Handbook, distinguish charrettes from other workshops by emphasising their intense, collaborative nature, their holistic approach, and

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[7] Details on the North American activity available at (www.charretteinstitute.org)

their focus on a feasible solution. [LENNERTZ 06] NCI charrettes last four to seven days, on-site, and often integrate a surprisingly amount of public review and input into the process, as illustrated in Figure 24.

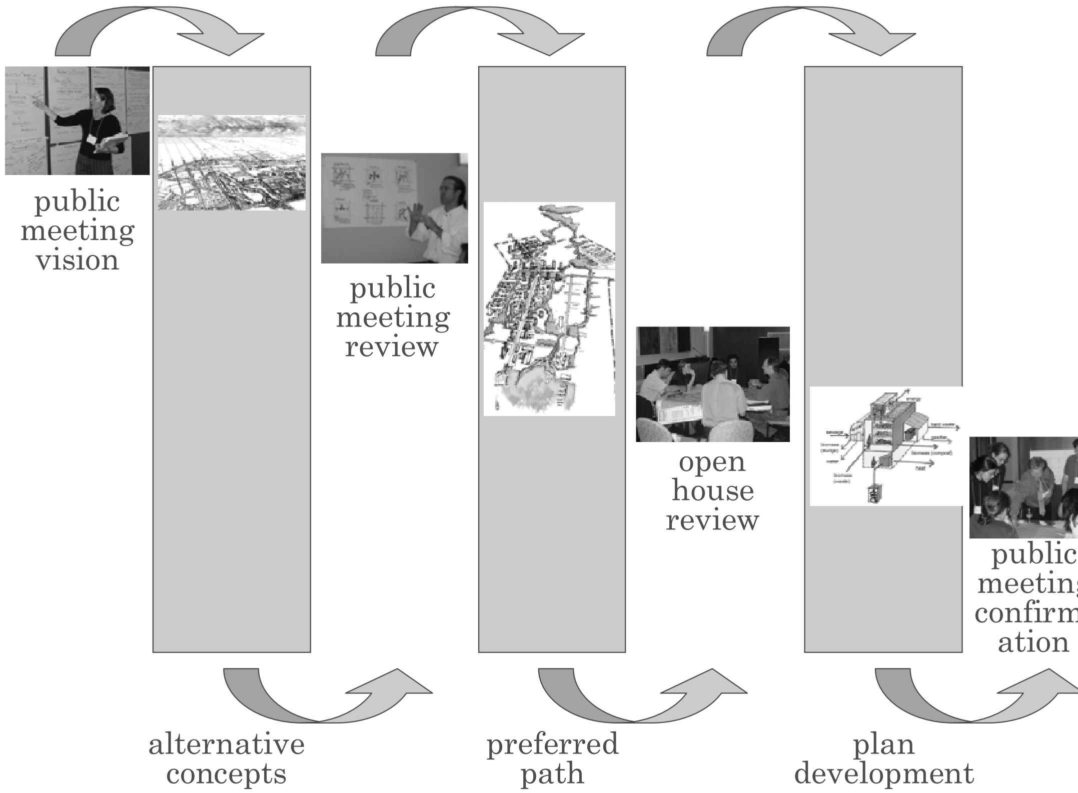

Figure 24 Charrettes of four to seven days may include substantial public input [Adapted from LENNERTZ 06, with graphics and photos from CITIESPLUS 03]

Urban scale charrettes are much less common. Most of the pioneering work has occurred at the University of Washington, under the direction of Douglas Kelbaugh, author of *Common Place: Towards Neigborhood and Regional Design* [KELBAUGH 97]. Beginning in 1985, the charrette format at UW quickly evolved into a five-day workshop in which competing teams of advanced undergraduate and graduate students, led by design professionals, work on a selected urban design problem of civic importance. Although sponsored by academics, the goal of these exercises was to put forth feasible and creative solutions to real problems for real clients, as opposed to solving theoretical or academic problems. At the conclusion of the charrette, each team presents its proposed solution to a large audience of students, faculty members, planning professionals, and business and civic leaders.

The U of Washington Charrette process was later adopted by the School of Landscape Architecture at University of British Columbia, under Patrick

Condon, who used charrettes to explore alternative suburban growth models for four communities in the Greater Vancouver area. [CONDON 96] [CONDON 99] This work continues as part of the School's Design Centre for Sustainable Communities and their work with *Smart Growth on the Ground* – a multi-partner program in community research and re-design in British Columbia.

The university charrettes, and the follow-up case study work, represent a type of design-driven research referred to by Jack Breen as '*Designerly Workshop Based Research'*, in which a workshop is set up consciously as an experimental, simulated working environment. A 'construct' is set up for the purposes of empirical studies, the process is monitored, and rules are imposed to create a common platform for systematic comparisons and in-depth analysis. [BREEN 02]

4.1.4 Technology Scans and 'S' Curves

Technology scans involve scanning media for trends in technology. Technology scans can help to alert designers to the likelihood of new technologies that are not now in the marketplace. It then becomes possible to examine implications and to identify potential threats and opportunities at the local scale.

By extending time scales for scans it sometimes become possible to recognize patterns – innovation cycles like the Kondratiev waves, efficiency trends, exponential growth curves, technology substitution. With these different patterns in mind the scan seeks to confirm or reject the existence of patterns that project into the future.

Accurate interpretation of the scans depends on having good contextual information. Technology is now changing at such a fast pace that it is difficult to connect specific innovations with the driving forces. For example it has been frequently argued that the massive shift in North America from automobiles to SUVs (trucks) for personal transport reflects the impact of a flawed public policy on the profitability of truck sales relative to cars, and is not a rational choice by consumers in a free market. If policies and marketing campaigns can distort consumer preferences to such extent, how does a designer project the availability and diffusion rates of innovations such as hybrid electric vehicles?

One important context for technology scans is 'S' curves which can often be used to describe and predict penetration rates for innovative technologies. The Malthusian growth model is the direct ancestor of the S-curve or logistic function.[8] Although first applied to biology, the 'S' curve describes

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[8] Pierre Francois Verhulst first published his logistic growth function in 1838 after he had read Malthus' *An Essay on the Principle of Population*.

the growth of almost any population set that is growth limited. It is essentially a logistic function which depicts an initial slow change, followed by a rapid change and then ending in a slow change again. This results in an "S" shaped line when depicted graphically. In the case of technology, the initial adoption is very slow but increases exponentially once accepted; then as competition arises, or critical resources become scarce, the growth slows down – culminating in a 'mature' market. Most technologies are limited by either physical laws like thermodynamics and material quantities, or market factors like income and demographics.

Jones, writing in *Forecasting Technology for Planning Decisions*, explains that any technological innovation that is ultimately limited, will follow a characteristic S-curve on a graph. As shown in Figure 25, the S-curve is challenging for designers and decision-makers. Initially the pace of diffusion is slow and expectations are too high; then the steep rise occurs and everyone is surprised as the technology takes off; and finally the limit is reached, and many planners fail to reduce their investment accordingly. Jones also describes the common phenomenon of sequential technological innovations substituting over time, essentially creating a daisy chain of S-curves that represent a super S-curve. [JONES 78]

When viewed from the perspective of S-curves, the current world-wide investments in large scale infrastructure projects –sewage treatment plants, remote thermal generating plants, super highways – risk becoming a classic example of overinvestment in mature technology.

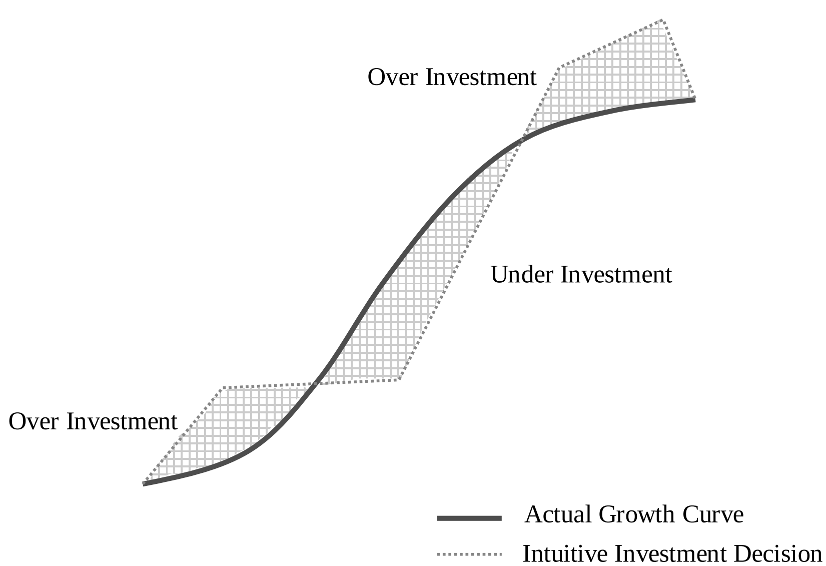

Figure 25 The risk of ignoring S-curves is substantial over or under-investment in urban system technologies [from JONES 78, redrawn by author]

Exponential rates of change describe many phenomena in the urbanised world: the use of the Internet and e-commerce, the rise in computing power and machine intelligence, the life expectancy of humans, the economic output of a worker, our knowledge base, and the growth in international trading. In all cases the apparently sharp transitions, which may be experienced as surprise, become straight lines on logarithmic graph paper.

Moore's law is a good example. In 1965 Gordon Moore, co-founder of Intel, predicted that the density of transistors on a computer chip would double every eighteen months. In other words, computers become twice as powerful, or half the size, every 1.5 years. In fact the density has been doubling at this pace for five decades – and possibly longer if consideration is given to the origins of computing devices (the mechanical calculator used in the 1890 US Census, the Turing engine, and so on). The rate of doubling has now accelerated to twelve months - and the pattern is expected to continue at least until 2020 (when the circuit boards are only atoms thick). This creates the daisy chain S-curve (Figure 26) and ultimately ends in a 'singularity' beyond which lies deep uncertainty and possibly a whole new paradigm for computing technology.

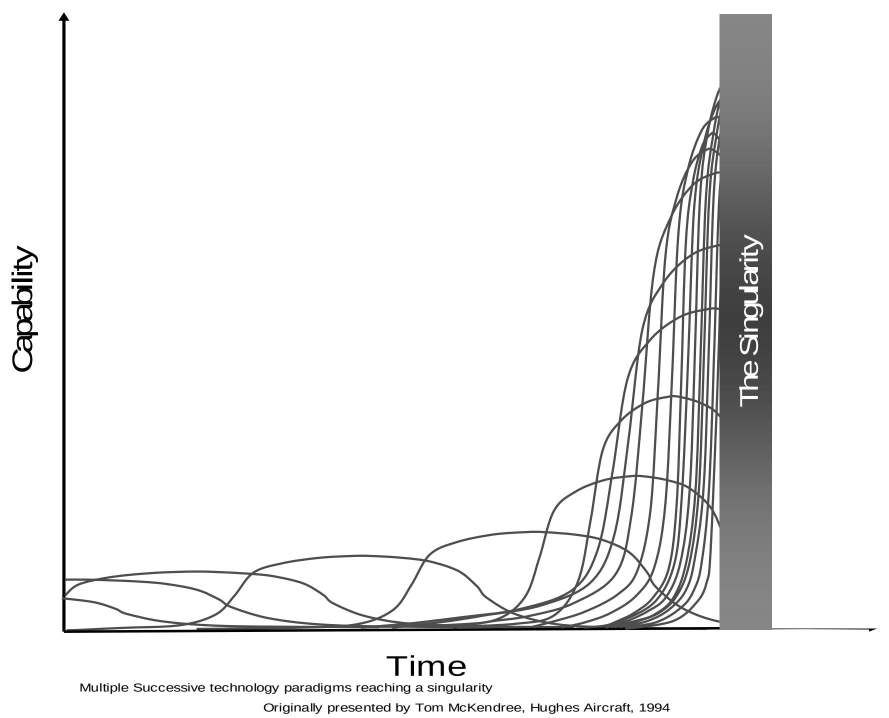

Figure 26 Multiple successive technology paradigms for a daisy chain of innovations but at some point near 2030 reach a singularity [referenced in BRAND 01 and originally presented by Tom McKendree, Hughes Aircraft, 1994

Ray Kurzweil, writing in his book *The Singularity is Near*, predicts that the rate will continue past this horizon, as the computing systems switch to yet another technology – a change he refers to as the sixth epoch. He lists a confusing array of principles and trends that in total suggest that the singularity represents a true event horizon. His guess is that past the singularity most of the intelligence of our civilization will quickly become non-biological. “By the end of this century it will be trillions and trillions of times more powerful than human intelligence.” [KURZWEIL 06] [KURZWEIL 01] Despite our history with computers, and the indisputable trends, such exponential change is difficult for a designer to comprehend, much less integrate into design and investment strategies. However with greater S-curve literacy, technology scans may provide important insights into future conditions and design opportunities.

4.1.5 Decision-Analysis

Decision trees, influence diagrams and belief nets are examples of simple, graphical tools intended to facilitate communication between groups of analysts and decision-makers. They represent the ‘front end’ of a decision analysis, and have been popularized by Howard and Matheson as a way to solve complex real-world decision problems. [HOWARD 81] [OLIVER 90] As a heuristic, they may be well-suited to the complexity of longer-term design decisions and to communicating the interdependencies of urban systems over time.

The most basic approach is to display all possible outcomes of decision chains by graphically and chronologically representing the elements in a decision tree. However rather than show every possible decision and variable, an influence diagram can be created that shows only the dependencies amongst variables, and is thus exponentially more compact as shown in Figure 27. The nodes in the influence diagram are typically classified according to decisions, uncertainties and values, with the relevancies or dependencies shown by arrows. Influence diagrams have been promoted as powerful tools for structuring and facilitating dialogue amongst people with diverse backgrounds.

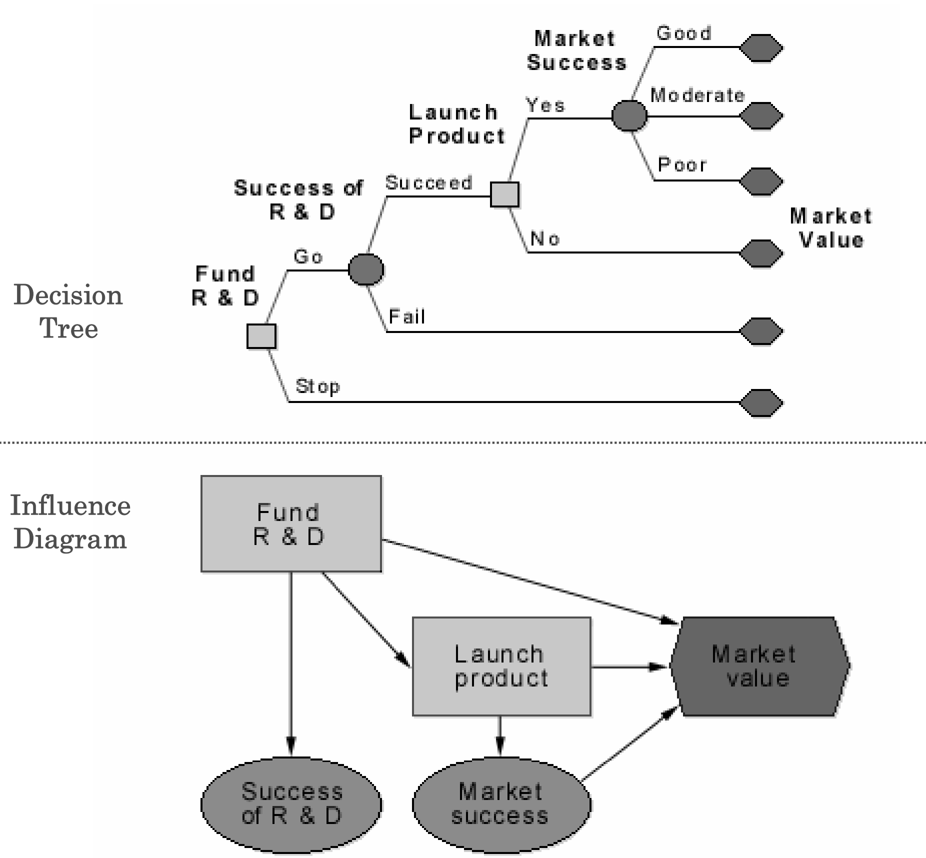

Figure 27 Even a small portion of a decision tree is unwieldy when compared to a corresponding influence diagram [from ANALYTICA 05]

For many people an influence diagram is easiest to understand as a series of cause and effect chains, although strictly speaking the causality is not always direct, or restricted to the elements shown, and thus the term 'influence' or 'relevance' is used. They are easy and intuitive to draw; they allow easy numerical assessment; and, most importantly, they visually communicate independencies between variables. By visually displaying their changing assumptions, they allow groups to focus on internal dependencies as a whole, rather than in disjointed sections. Aspects of inference, prediction and decision can be drawn using simple nodes and arrows, and discussed at a non-technical level. Thus they reinforce a systems perspective. They also can provide a foundation for more complex modeling between groups.

In addition to clarifying system dynamics, influence diagrams can also produce statistical calculations. In a probabilistic influence diagram, the nodes represent random or deterministic quantities while directed arcs indicate possible (not actual) dependence. Attached to each node is a conditional probability function for the node, which depends on the states of the adjacent predecessors' nodes. [OLIVER 90]

As a preliminary step to creating influence diagrams it can be useful to employ knowledge maps or mind maps. These maps help to create a spreading tree of potentially relevant factors and subsidiary factors related to an issue of interest, and can be used to develop clarity about the key relationships and factors.

4.1.6 Simulation Models

Simulation models can help to further clarify future possibilities by predicting how the elements of a system might change over time as they interact at various scales, and in particular, how such interactions might cause significant deviations from past trends. [LEMPERT 03] In essence the models combine extensive knowledge about current conditions with mathematical assumptions about key causal relationships between the elements of the system. Models may be the only approach for simplifying the complex real-world problems of urban system design, and allowing designers and decision-makers to obtain answers to their 'what-if' questions.

Models for environmental impacts and urban system design are complex, and in practice are always incorporated into a software tool – thus creating a Decision Support System (DSS). The structure of the model and the computer interface will depend greatly upon the tool's intended user and specific application. In broad terms the models fall into two categories, despite many variations and hybrids. Some models are intended to assist with forecasting system performance in response to many separate relationships interacting – sometimes referred to as general equilibrium models. Others are intended to assist with selecting appropriate design strategies and specifications. Both types of models assist with time extensions, and have relevance to sustainable urban system design.

Among the few truly long-term equilibrium models the best known is the *World3* model used for the Club of Rome's *Limits to Growth* study. The surprising results from this model, the ensuing controversy, and the continued debate over both the accuracy of assumptions and the validity of the predictions, point to the strengths and the weaknesses of simulation models. The principle strength is that models do not depend entirely on trends, and thus they can reveal plausible futures based upon interactions over time. The weakness of models is that assumptions about relationships often rest upon unpredictable dynamics. For example, how will the market react to scarcity and high prices, or to innovations? How will climate respond to greenhouse gas emissions or to melting ice caps? How will reproduction rates respond to rising income and education levels, or to urbanization? These potential feedback mechanisms may be unknowable, and tend to undermine the credibility of forecast models.

At the opposite end of the scale it is possible to use simulation models for physical processes within buildings and neighbourhoods, where feedback mechanisms are well known and can be fully integrated. A host of robust sub-models of this type are available for exploring the near and mid-term performance of constructed environments, including urban regions. The best known examples are thermal simulation models for buildings, lighting models for day-lighting, dispersion models for air pollutants and transportation models for congestion and cost.

In between the world models and the micro models are a series of urban and regional tools for urban design, including energy models (e.g. MARKAL, LEAP, Cities For Climate Protection, LICONSULT) water models (e.g. IWR-MAIN, TDM Model, InfosNet) transportation models (EMME/2) and land use models (e.g. QUEST, INDEX). [ANNEX 31] Most of these models are design tools. Some regional models incorporate micro-model outputs, through sub-routines and aggregation. They may also allow users to input key assumptions, and then predict outcomes based upon the personalised inputs.

User-defined assumptions add a time and knowledge burden, but help to avoid the controversy associated with 'black box' models. Control over key assumptions makes a model more appropriate for collaborative exercises where many of the assumptions may actually be within control of participants. Even where key assumptions are largely exogenous to the influence of designers, providing some user choice may have benefits in terms of transparency, and comprehension.

Perhaps the most ambitious modeling efforts are the large-scale urban system models developed for policy analysis. These models typically integrate land-use and transportation systems according to spatial interactions that are embedded in encompassing demographic-economic frameworks. By modeling the behaviour of various urban actors, urban system models are able to forecast urban development patterns. They are capable of investigating the ways in which economic, land-use, and transportation policies affect the entire urban system. At least a dozen operational large-scale urban system models are currently being applied to urban regions for the purpose of policy analysis or research. [WEGENER 94]

While simulation models are almost universally expected to play a key role in long-term design, current use of such tools at the scale of urban systems is extremely limited. Difficulty with tool usage has been attributed to uncertainty about interdependencies, uncertainties about which data and scenarios were used, ignorance about key input assumptions, dispersed data, and a difficulty keeping track of scenarios. [KERSTEN 2000]

4.1.7 Scenario Planning

Scenarios first emerged as a planning tool in military context when, following World War II, the US Air Force examined alternative doomsday possibilities. Harman Kahn, who was part of the Air Force effort, later applied the technique to business and economics. [KAHN 76] Pierre Wack, a corporate planner from Royal Dutch Shell, visited Kahn and decided that scenarios might be a way to prepare Shell for what he saw as an inevitable shock in oil production in the Middle East. Working with a team of planners he had some success in preparing Shell for the oil crises in 1973, although he was personally surprised at how little success. In writing about the experience in a 1985 article on "The Gentle Art of Reperceiving" he describes the difficulty, and concludes that scenario planning is not so much a technique for planning, as a kind "of in-depth training over time. You research present key trends; you determine which are predictable and which are uncertain; you decide which uncertainties are most influential; you base some stories of the future on those uncertainties; you spend some time imaginatively playing out the implications of those stories; and then you use those implications to start all over again and develop a sense of the impending surprises that you cannot ignore." [KLEINER 03]

Schwartz, who worked with Wack and helped to popularize the method in the corporate world, defined the scenario process as providing "a context for thinking clearly about the impossibly complex array of factors that affect any decision …for challenging mental models about the world." [SCWARTZ 91] Scenario planning can be described as organized dreaming, future memories, new myths, and story-telling. "Scenarios acknowledge uncertainty and aim at structuring and understanding it--but not by crisscrossing variables and producing dozens of outcomes. Instead, they create a few alternatives and internally consistent pathways into the future. Scenarios describe different worlds, not just different outcomes in the same world." [WACK]

An essential element in scenario planning is the identification of driving forces. Driving forces move the plot of a scenario, and determine the story's outcome. Without driving forces there is no way to begin the development of a scenario, since they determine which variables are most significant. Schwartz derives relevant driving forces by selecting from a list of five categories: society, technology, economics, politics and environment. [SWARTZ 91] Global scenarios tend to focus on demographics, economy and the environment. Ratcliff proposes 8 forces for design of the human and built environment: demographics (population change and ageing); climate change (sustainability, environmental pressures); urbanisation, (growth of cities, transportation); people and quality of life; materials and technologies; vulnerability and security; globalisation of economics and business; information, knowledge and communication; governance, legislation and government intervention. [RATCLIFF 03]

Despite the availability of scenario planning guides for cities and case studies, and their potential value, the method is intellectually challenging and seldom applied as part of long-term decision-making. A researcher at LBL makes the case: “In my fifteen years of involvement with development of national energy policy, I have been most struck by how few resources are devoted to sensible scenario development and associated data, and how much to the development of different modeling tools to assess such policies. …The policy makers fail to realize that models are all unable to predict the future in an accurate way, and that small improvements in modeling methodology are made irrelevant by inadequate scenario development.” [KOOMEY 2000]

In the last few years scenarios have been commonly used at the global scale to model economic and environmental futures. Two of the best examples are the Special Report on Emissions Scenarios (SRES) [NAKICENOVIC 99] produced by the United Nations Intergovernmental Panel on Climate Change (IPCC), and the Global Scenario Group (GSG) [RASKIN 02] convened by the Stockholm Environmental Group. SRES used six different integrated assessment models to create 40 scenarios. Drivers covered economic, demographic and technological forces, with varying degrees of globalization and environmentalism. The resulting scenarios were revealed to scientists the divergent possibilities for greenhouse gas emissions over the long-term, based upon current levels of uncertainty.

The GSG scenarios were more action oriented, and combined detailed results of quantitative simulation modeling with eloquent narratives – or “future histories” - that describe in words what each of the futures might be like to live through. Figure 28, reproduces the six broad scenarios forecast by GSG, and shows the very large differences in world per capita income and population. [RASKIN 02]

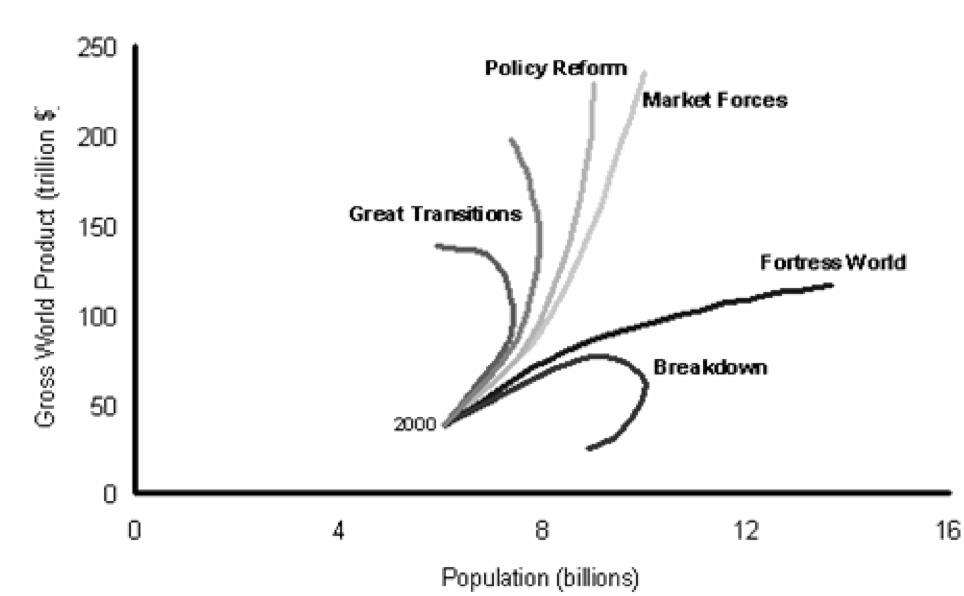

Figure 28 Long-term forecasts reveal multiple plausible futures for key factors such as population and wealth [Global Scenarios Group, Telus Institute, Boston, 04]

Most scenario planning is conducted by large corporations or international think tanks, not by urban designers. In fact scenario planning is not normally taught in the design professions, nor is there any detailed texts to help urban designers cope with the difficult process of creating scenarios. A few examples exist of cities that have conducted extensive scenario planning, focusing on growth management for example. The City of Ottawa, for example, evaluated 17 urban growth scenarios as part of their long-range plan OTTAWA 2020; an experience the staff described as "exhausting".[9]

One of the first published examples of comprehensive scenario planning for urban system design is the *urban futures management model* proposed by Hasan Ozbekhan for The Future of Paris: A Systems Study in Strategic Urban Planning (1977). [OZBEKHAN 77] The model is shown in Figure 29, and includes identification of trends, use of trends to project logical futures, the change of paradigm and the creation of 'willed' futures, the reconciliation of alternative scenarios through strategic consensus and the identification of policy gaps and the creation of implementation plans. Now three decades old, the model remains as a useful map of the process of long-term systems design. No effort was made to produce a generic version.

[9] Personal conversations between author and city planning staff.

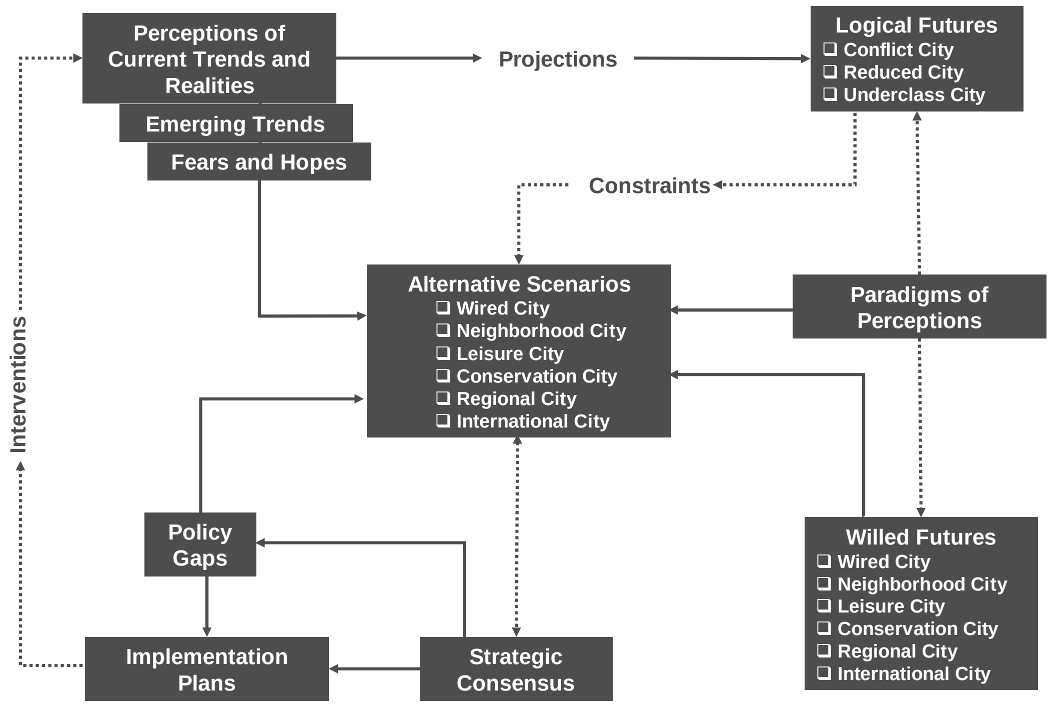

Figure 29 The Urban Futures Management Model for systems planning in Paris shows how consensus can be achieved by examining interventions, projections and constraints [from OZERBEKHAN 77, completely redrawn by author]

A key goal of scenario forecasting is to find design solutions that are likely to prove sufficiently robust to survive well whichever of the anticipated futures eventually unfolds. [LANKSHEAR 2000] In the context of urban design, scenarios may also help to avoid disputes and instead move discussion onto common ground: – the future is unknowable, yet something we all share; it is where our values converge, and where we all become related as our progeny intermarry. Creating scenarios is like building 'museums of the future'. These are public places where we go "to explore the full range of future possibilities, and become comfortable with choice, while recognising that none of the exhibits will fully capture the unknowable and unpredictable reality to be." [LYNCH 91]

4.1.8 Scenario Backcasting

A fundamentally different approach to scenario modeling begins with a future vision of a desirable and feasible outcome, and then works backward, attempting to identify plausible design strategies and policies needed to get there from the present state. This normative approach is known as backcasting. Amory Lovins carried out pioneering work in this field through his analyses of soft energy paths [LOVINS 1977]. Various types of backcasting have been used in management theory for many years. For example ‘Future Perfect’ strategies, coined by Schütz in 1967, encourage managers to picture projects as completed so that they gain the temporal aspects of ‘pastness’, then they can interpolate their way backward into the present reality, and manage implementation more powerfully. [SHÜTZ 67] Future Perfect strategies allow people to become familiar with projects that exist in both past and future, and align action towards what will happen, rather than what might happen. [PITSIS 2001].

Since the early 1980s, John Robinson has advanced the backcasting approach through research on both methodological and theoretical issues [ROBINSON 82, 88, 90, 91, 92). More recently, Karl Dreborg has traced the theoretical assumptions underlying the backcasting method. [DRE 96] The approach has been widely applied to urban planning issues as part of The Natural Step (TNS), a method for helping businesses and municipalities define pathways for long-term sustainability. [HOLMBERG 2000] [ROBÈRT 02] [JAMES 04]

Backcasting shifts the prevailing objective of modeling from one of prediction to one of choice, or in Dreborg’s terms, from a focus on causality to a focus on teleology. This shift is based on two main realizations. Firstly, modeling activity is not a neutral and detached endeavour, but is rather an explicit part of the political arena in which planning decisions are made. Due to the political nature of modeling, a closer relationship is needed between users and analysts [ROB 88b]. Backcasting aims to meet this need by involving relevant interest groups in the modeling process in a much more direct and active manner than conventional modeling approaches. Such participation allows for active social learning during the modeling process. Fedor Gal and Pavol Fric describe scenario planning as one of the essential ingredients in a participatory approach to planning. They argue that do-it-yourself forecasts are a means to reach consensus on future actions, and that this is the “first practical step towards a desirable future”. [GAL 87].

Secondly, predictive models have the effect of influencing the behaviour and design through reaction to the forecasts themselves. [BAUM 87] Forecasts can bias decisions such that modeling of complex systems acts to legitimize, rather than inform, decisions. The solution is to maintain a clear separation between modeling activity and decision-making. Backcasting attempts to achieve this by explicitly separating physical processes from policy and design-related choices. This approach opens up much greater latitude for normative modeling, where futures are created to meet specific goals. Design strategies become an explicit part of a political process.

In comparison with scenario forecasting, backcasting is more readily integrated into participatory processes and collaborative decision-making.

Backcasting is especially suited to long-term design, where the visions are critical tools for design, and where many aspects of the system become uncertain and open to influence. Dreborg argues that backcasting is most appropriate when the problem is complex, major change is needed, dominant trends are part of the problem, externalities are the major factor, technological innovations are a factor, and most importantly, the scope is wide enough and the time horizon long enough to leave considerable room for deliberate choice. "It is an approach which may promote creatively, by shifting the focus from the present conditions to a situation sufficiently afar off in the future to permit radical change." [DREBORG 96]

Dreborg introduces a possible third rationale for backcasting, by focusing on the likelihood of "big surprises". He argues that it is impossible to predict the impact of completely new ideas and knowledge, a factor which contradicts the premise that social systems can be forecast over the long-term. As forecasts become less certain, the balance shifts to questions of how to influence the future within a full range of future scenarios.

Backcasting has a rigorous logic that is surprisingly effective at engaging business and community leaders. Once agreement – an understanding - is reached on the long-term constraints and desired end states, the design exercise becomes a creative and cooperative process of seeking the preferred implementation strategies – i.e. strategies that are fast, low-cost, low-risk, multi-functional and permanent.

The Natural Step (TNS) is an international backcasting method initially promoted as an approach to introducing sustainability to the business community. TNS began in 19xx when the founder, Karl Henrique Robert, began to translate ecological limits into simple, executive terms for sustainable business planning. From these small beginnings TNS has evolved into a design tool that is now in use in 60 plus eco-communities in Sweden, [JAMES 04] and others worldwide. In Canada it has been adopted by business and community leaders in the Resort Municipality of Whistler – arguably Canada's leading example of sustainable development practice.

The strength of the TNS framework is the clarity and simplicity of the end-state principles or system conditions, and the process by which environmental strategy is designed to align with these principles. In order for a society – and communities and businesses – to be sustainable, nature's functions and diversity must not be 1. systematically subject to increasing concentrations of substances extracted from the earth's crust; 2. systematically subject to increasing concentrations of substances produced by society; or 3. impoverished by over-harvesting or other forms of ecosystem manipulation. A fourth principle holds that resources be fairly and efficiently used so as to meet basic human needs worldwide.

The TNS Framework is best known for the use of an iconographic funnel, shown in Figure 30. The challenge presented by the funnel is to adjust the way in which towns and cities and corporations conduct their affairs, so that within a few decades all activity conforms to the fixed limits.

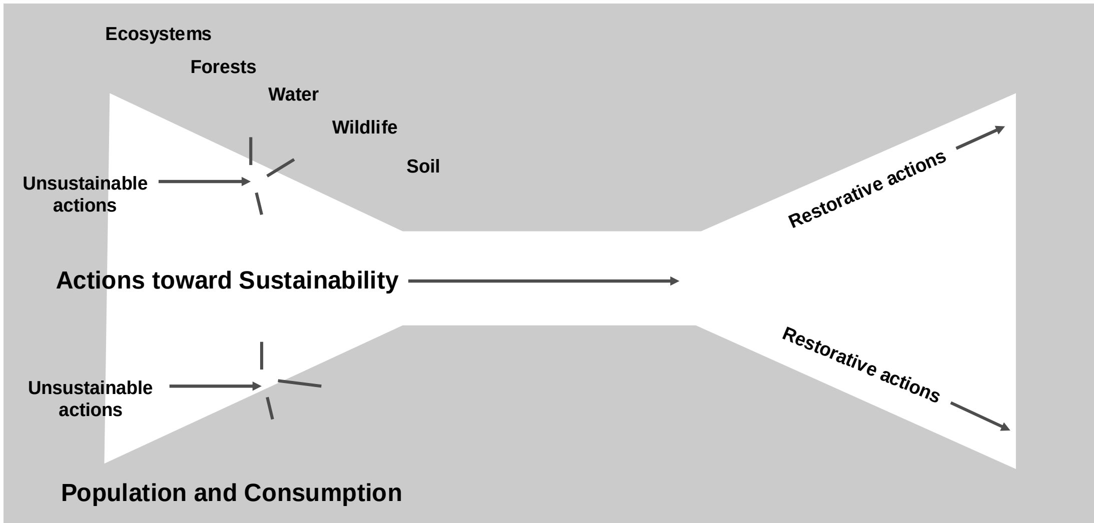

Figure 30 The Natural Step uses a funnel to illustrate the backcasting approach to achieving sustainable resource use over time [JAMES 04, redrawn by author]

TNS is conceptually weak, since the system limits are indistinct, do not directly address the role of ecologies, and ignore the need for adaptation and resiliency. The funnel is not actually calibrated to any process of change management (S-curves for example) or to key driving forces, which limits its use as a heuristic. TNS is not specifically designed for use with urban systems, which makes the application difficult to transfer directly to urban designers. Despite these limitations it has proven to be a highly effective tool for building consensus across private and public sector groups at the community scale, and is one of the only practical examples of backcasting with long-term horizons.

A central weakness of backcasting as a method, and thus of tools like TNS, lies in the operational details. Firstly it is difficult to establish end-state definitions, especially in areas such as culture and economics. Secondly it is difficult to communicate the logic of the scenarios to the community at large, which can leave the core design team, and their champions, exposed to criticism within the media. Thirdly, the pathways are not easy to construct, due to the range of choices available. What seems to be missing is a logical process or integrated approach that can guide the development of backcast scenarios. Such a process may need to methods for: sequencing the various policy tools and design strategies; setting boundaries on the pace of transformation, developing interim goals and metrics; and counteracting negative trend lines and catalyzing (or managing) rapid change.

4.2 What Methods can be used to assess long-term performance of systems?

A review of methods and tools has revealed an array of possible approaches that may be adapted to long-term, sustainable urban systems design. However none of these approaches are sufficiently well adapted to provide comparable assessments of performance at the regional scale, or to accommodate changes in time concepts. For this purpose an exploration will now be undertaken of two assessment methods that may possibly be adapted for this purpose: Life Cycle Analysis and Materials Flow Analysis.

4.2.1 Lifecycle Analysis and Time Extensions

Life Cycle Analysis (LCA) is basically an accounting of mass and energy flows over the life cycle, using system ecological methods [HEIJUNGS 92]. Over the last twenty years LCA has become a well-documented and internationally standardised method [SETAC 93 and 96] [ISO 14040 series]. The sophistication of the environmental accounting is substantially greater than any alternative. Hof summarises the state-of-the-art of the method [HOF 98] [GUINEE 01][LCIA 03]. A new standard under development. [ISO 14048]

LCA differs from most other environmental costing and assessment by extending time scales both forward and backwards. A product's life cycle starts when raw materials are extracted from the earth, followed by manufacturing, transport and use. The life cycle ends with waste management including recycling and final disposal. At every stage of the life cycle, resources are consumed (or transformed) and emissions pollute the air, land or water. These environmental loadings (or stressors) impact the environment functions upon which humanity and the biosphere depend. Because significant environmental impacts can arise at each stage, a fair and accurate environmental assessment of any product or service must take into consideration the whole life span. What makes LCA different from other environmental assessment tools is a capability to integrate time-dependant inputs and outputs as part of environmental accounting. Thus it can be argued that LCA is essentially a tool for addressing time in sustainable design - a timing tool.

LCA attempts to aggregate the many environmental effects of products and services over their lifetime and translate the effects into a manageable number of impact indicators, allowing designers and buyers to quickly understand the strength and weakness of alternative materials or designs. The large majority of LCA method development and research over the past

20 years has focused on the evaluation of either basic commodities - like concrete, fuel, lumber and steel – or manufactured products and associated services - like furnishings, pharmaceuticals, packaging and transport. This existing body of research work has not only helped to define standard methods, but has also created an essential database on embodied emissions and expected lifetimes for most materials that circulate through the economy. [ECOINVENT 06].

While LCA is working well for many industrial processes, it has proven more difficult to apply LCA to elements of the built environment, whether at the scale of buildings or entire urban regions. In the early 1990s efforts began to aggregate LCA data so that it could be used as a decision-making tool for planning and design of buildings, stocks and infrastructure. [REGENER 97][IEA 2000][CIB 98][SETAC 02]. Aggregation of LCA data means that instead of focusing only on basic process (like energy transformation, material production or transport process) LCA results are added up to include functional elements of the built environment on-site. Essentially the physical scale of the analysis expands from a base of commodities and products, through a series of nested 'environments' including constructed assemblies like walls or roads, to whole buildings systems and their surrounding site, to neighbourhood developments with buildings and infrastructure, and, conceivably, to entire urban regions. Although this expanding physical scale is a continuum, the most effective scale for analysis is typically at the level where decisions are most likely to influence the system dynamics. Two scales are especially relevant –the scale of a whole building, and the scale of an urban region. The building scale LCA can inform the local design team, and then be scaled up to inform urban system design and planning policy. [KOHLER 2000] [KOHLER 2005]

Aggregation introduces an unavoidable element of complexity. A single building may comprise over 60 basic materials or commodities, and around 2000 separate products, each with their own lifetime and unique production / repair / disposal processes. As a consequence, data collection and allocation decisions for any particular building are far in excess of the capability of most design teams or decision-makers. A great number of default assumptions are required, and even still the task is complex. Moreover the long life of most buildings means that typically more material and energy will be expended during the operation phase than was invested in the initial construction. Scenarios must be constructed for predicting the nature of these future investments, including the estimated life spans and disposal routes for materials. Thus the estimation of resource flows over the life cycle is influenced by a complex system for analysing the construction process and the composition of many elements, including basic upstream data on industrial processes, and assumptions about how a building, and all of its elements, will transform over time.

The data complexity requires that research and policy institutes collaborate with industry to assemble material inventories of basic data sets, in ways that ensure data remains up-to-date, easily accessed and packaged at levels of precision appropriate to user needs. For each phase in the building life cycle the basic data sets must cover all major flows, including energy, water, basic commodities and auxiliary materials [BUWAL 95].

Complexity also emerges as a challenge when trying to compare options, and communicate results in ways that are easy to understand and act upon. The choice of must take into account the nature of the building and the objectives of the LCA. Traditionally the reference points vary depending upon who is doing the measurement, at what stage in the design. The choice of a reference or functional unit (e.g. the building as a whole, a square meter of floor space, an occupant, a dwelling unit) involves difficult trade-offs, especially as buildings become more integrated with the community, and more multi-functional.

The site-specific aspects of buildings and urban regions can also create challenges. For many industrial products, LCA can work with gross assumptions about where and how the product will be used, or 'released'. The location of use is an abstraction - the 'economy' or the 'average marketplace'. But for a building, the location of use is the site – a key variable for consideration in design and management decisions. At the most local scale, a building site creates, by definition, an indoor environment – where the potential impacts of concern include worker productivity and occupant security, comfort, safety and health. LCA tools do not normally address these effects, and thus a combination of tools may be required.

When the scale expands beyond the isolated building, effects can be assessed on the parcel and the surrounding neighbourhood. Localised effects may include the urban microclimate, solar and wind access for adjacent buildings and gardens, neighbourhood security, noise, public amenities, biodiversity and bio-productivity. At the regional scale, the building and its systems will place demands on the community, affecting air quality and public health, economic development, the use of transportation systems, emergency preparedness, the loading of urban infrastructure systems and the allocation of local ecological carrying capacity. Each scale will be affected by the building's use of resources, and associated emissions. However once again LCA does not normally address these impacts and an expanded set of analytical and evaluation models may be required.

Fundamental to any LCA application is extending the analysis along the time scale, both upstream and downstream from the moment of construction. By looking upstream, the analysis captures crucial aspects of the supply chain. Electricity, for example, can embody very small or very large emissions, depending upon the regional 'supply chain' for power. By looking downstream in time, it becomes possible to account for the cumulative effects of operating the building, and the recurring costs associated with repair, replacement and rehabilitation. Disposal of the building can also be addressed, at least in the form of recommendations. The use of recycled materials or elements will carry fewer impacts because LCA protocols account for impacts with the first use. This way of accounting punishes the (first) extraction of materials from nature and favours the conservation of an element (or building) in the use cycle as long as possible.

Such "future accounting" provides crucial information for design and investment. Over its lifetime a typical building or infrastructure facility will experience periodic renewal of the interior finishes, equipment, landscaping and even the exterior veneers, all of which produces a flow of materials equal to, or greater than the initial construction. In theory, the future performance of these physical systems can be improved through increased efficiency, adaptability, durability and design for disassembly. Such decisions are best made early on since the potential for influencing the full life cycle performance is very high in the early stages of design, and decreases dramatically as time goes by. [KOHLER 05] LCA is especially effective in alerting decision-makers of important downstream impacts.

In order to adopt the extended time horizons required for LCA it is necessary to make assumptions about how buildings are to be used, expected lifetimes of the components, innovation cycles for new technologies, and the changes that will occur as a result of external forces. [BUERGEL 05] Such detailed predictions are notoriously difficult and the only practical solution is to use 'frozen futures' by sharing and standardising all of the assumptions used for the downstream scenarios. It has been argued that a frozen future is dangerous because it embeds highly speculative assumptions in a method that is otherwise quite rigorous. For example LCA can mislead users by obscuring the potentially massive impact of technological change, and the importance of risk management and resilient design. The only solution may be to combine LCA with more goal-oriented tools like Strategic Environmental Assessment [SEA] and to use LCA to assist with scenario planning tools. [ROB 2000]

At the scale of buildings and urban systems, it may be impossible to effectively use LCA without support from simulation models that can account for the complex interactions between systems. The choice of structural system, for example, affects the mass of the building and footings, the type of insulation materials and energy demand, the thermal inertia and resiliency of the building, the potential for immediate recycling and long-term reuse, and the transportation and industry systems that supply the materials. [TRUSTY 05] These types of relationships are often the most important consequence of design choices, and thus it is risky to view any element of a building in isolation.

LCA and the Performance of Entire Building Stocks

In the late 1990s researchers employing LCA for buildings began to see the potential for analysing entire building stocks, using the same methods and tools [JOHNSTONE 95][MOFFATT 00][HASSLER & KOHLER 02][SCHWAIGER 03]. By classifying buildings into archetypes or categories, and then aggregating the LCA results for each archetype to reflect the total population of buildings that fit the archetype, a picture emerges of the entire mass and energy flow, and environmental impacts, for buildings at the scale of the urban region.

Scaling LCA to include entire building stocks offers advantages over traditional top-down approaches. The precise data sets used for the archetypal buildings allow exploring alternative policies at a high level of resolution. For example by creating new archetypes, and by varying the numbers of buildings falling within each archetype, it is possible to forecast the penetration of hypothetical policy and to measure the net impact on the local economy and ecology.

Moving the spatial scale from the building to the stock of buildings is similar to moving from products to buildings. A foundation of existing data at the micro scale makes possible a much more accurate forecast of flows and impacts at the macro level. And the new macro scale analysis creates opportunities to capture the larger system dynamics.

Initial efforts at modelling entire building stocks have emphasised the significance of policy related to the durability of design, and to the importance of individual building operation and maintenance. [SCHWAIGER 98] [YANG 05] In fact stock management may be the single biggest challenge for LCA in the coming decades. Using rough numbers from the World Bank, it is possible to estimate order-of-magnitude transitions worldwide[10]. After accounting for average turnover rates and WHO projections of population growth, the stock we have on the ground today – about a billion buildings world wide - represents approximately two

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[10] These rough estimates assume a world population of 6 billion, an average of 4 persons per household, a mix of 50% urban, 10 households per bldg in urban areas and 1 in rural, 30% of populace employed in commercial stock, 15m^2 per person in office or factory, 3000 m^2 per building, and a 20% increment for institutional and storage buildings.

thirds of the buildings that will exist 30 years from now. Over this time period the stock will be continuously transforming.

In the course of a ten-minute coffee break, about 160 buildings will be replaced, and another 200 new buildings added to the world's total. Each of these new buildings becomes part of the stock management challenge – once it is occupied and subject to a changing environment and economy. About half of these new buildings will have already undergone major refurbishment 30 years hence. The process never ends, because, as Stewart Brand says, "Nobody builds a building, they just start one" [BRAND 94].

Renovation and refurbishment is a major economic activity that in developed countries far exceeds the value of new construction. In the course of the same ten-minute coffee break, about 800 buildings will have been substantially refurbished. These rates of change may be even higher due to an accelerating pace of technological change, aging populations, rising income levels, climate change and so on. Can LCA help to manage this mutable, and growing stock of existing buildings to achieve a sustainable long-term situation?

At present there is very little integration between refurbishment strategies for individual buildings - or groups of buildings - and plans for sustainable community development. At present the refurbishment is focused on technical issues, or on satisfying internal constraints such as initial costs. However by conserving energy, material and water, the management of building stocks can substantially improve community economic development: 1. by circulating money regionally (instead of importing resources like energy), creating jobs, and generally making the entire economy more resilient and competitive; 2. by improving liveability, safety, affordability and cultural diversity; and 3. by using existing building capacity to avoid or reduce sprawl and congestion, homelessness and infrastructure capital costs. Upgrading the quality of the stock may even help to enhance a sense of identity and place within disadvantaged sectors of cities, although experiments so far have been less than satisfactory. [Swedish work and Estonia]

A difficulty with using LCA for stock management is that results must be standardized and sequenced so that relevant information is available in the appropriate form and at the right time for contractors, suppliers, maintenance personnel, owners, tenants, designers, inspectors, tax assessors, and realtors.

The Potential for Urban System LCA

Using LCA for complete urban systems means expanding scope of stock aggregation to include the many infrastructure elements that are connected to buildings, including roads, pathways, right-of-ways, parking lots, wires, pipes, ditches, bridges, and the associated treatment plants, sub-stations, open spaces and facilities. These infrastructure elements have exceptionally long lifetimes and can account for large quantities of lifecycle material and energy flows. Infrastructure design teams are often stable groups of professionals, already familiar with sophisticated software tools for planning, costing and management [MOFFATT 2000][HERZ 96][SCHILLER 02]. Thus LCA appears to be especially prudent for infrastructure design decisions including materials, systems and financing.

Sewer pipes, for example, may change from concrete to welded steel, if due consideration is given to durability, cleaning, maintenance and other recurring costs over the full life of the system, and to potential for adaptability and recycling. Road surfaces may change from asphalt to concrete, if due consideration is given to the improved efficiency and fuel savings achieved by trucks tires on concrete. Linear in-the-ground infrastructure grids may adopt 'combined trenching' and easily accessed 'utilidors', if these are shown to offer greater adaptability and lower operating costs over the long life cycle of such systems. Capitalisation of new infrastructure systems may need to incorporate on-going reserve funds, if LCA can project the long-term material and money flows needed for periodic repair and replacement.

Despite such potential benefits it would appear that no cities in Canada are currently conducting LCA or Life Cycle Costing (LCC) on materials and system design[11]. Even the concept of reserve funding is rare, since there is no legal requirement to put aside funds, and municipalities are chronically cash short. The principle weakness of LCA at the scale of urban regions is the lack of usable simulation models. Unfortunately the current potential for system analysis at the scale of urban regions is very limited, due to the complexity of the systems and the difficulty in accessing data. [BRUNNER 94][BACCINI 98] [MATSUMOTO 99] [MOFFATT 2000] [IFIB 03] [KOHLER 06].

Aside from the valuation data used for property taxes, most countries, cities and towns know almost nothing about the built environment, how it is constructed and operated. Even tax assessment data is frequently inaccessible, and the privatization of energy and water utilities compounds the problem of access to information. Management and refurbishment of existing stock and infrastructure is especially important in Europe, where longer-lasting systems have lead to relatively high flows of materials during

[11] This conclusion is based on discussion with Athena, the primary LCA tool developer, and interviews I conducted with a selection of consultants and urban planners across Canada as part of background research for the Canadian National Research Council InfraGuide program. [NRC 04]

the use stage. [KOHLER 99] A priority for rapid industrialising countries like China and India is to cut back on excessive amounts of heavy masonry used in construction, to convert the dirty energy systems that are used for producing materials, and to enhance the durability of concrete and other key materials that affect overall lifetime of buildings and infrastructure. [YANG 05]

A number of other weaknesses also present obstacles to the application of an urban LCA. A challenge emerges at the assessment stage of LCA, where the potential exists for confusion due to a variety of functional units and obscure evaluation criteria. In the near term, LCC and Life Cycle Inventories may be the only way to avoid confusion. Even this level of application is limited by the disproportional effort to introduce into software tools a large amount of specific mass and energy data, and to link the analytical outputs to cost planning, tender procedures and CAD systems.[12]

Urban LCA increases the diversity of players and the complexity information management. The complexity of LCA at urban scale is a problem recurring at every step. The scope of LCA can reduce the inputs, outputs, effects and impacts, and the analysis can be avoided by use of rules of thumb and checklists. However given the number of potential users and applications, the long-term solution may be user-scalable tools that start with a completed LCA /LCC on a typical or default system, and then limit the user inputs to match the required accuracy, and the time and information available at each stage of design. [LEGEP, 2002][KOHLER 05] [KOHLER and LÜTZKENDORF 02]. A scalable tool can help to preserve the rationale behind decisions for a more coherent and evolutionary design process. At the concept stage, information is requested on broad commodity performance data, using gross or average data – for example, allowing the team to compare wood, steel, concrete and combination structural components, assemblies and approaches. Later in the design process information requirements become more specific, allowing for a comparison of brands and procurement specifications.

Scalable LCA may help to compare options at the more detailed design stages, but it is not appropriate for scenario planning. The most environmentally friendly building or urban system is none at all, and thus the best starting point may not be a simplified urban system archetype with default values. For example, if a hospital building or a transit system can be eliminated by policies that care for people in their existing homes, or if adaptive re-use of exiting underused facilities can eliminate the need for

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[12] The links to cost planning have been realised in integrated LCA tools like LEGEP [LEGEP, 2003]; the link to CAD systems may be possible through the now released IFC standard [IFC, 2005].

more office or plant, this is typically a preferable approach. If topping up an existing dam, or retrofitting buildings, can eliminate the need for new power plants, then why invest in more infrastructure? If buildings can be situated close to public transport and bikeways, and close to associated places of work, shopping, school and recreation, what are the savings in transportation energy? If buildings can be mixed use and located close to infrastructure nodes is it possible to provide more efficient processing and an exchange of surplus energy, water and materials? Such questions are often excluded from the scope of design projects, and yet the potential impacts may exceed all other design options.

4.2.2 Materials Flow Analysis and Time Cycles

Materials Flow Analysis (MFA) is the study of energy, materials and water flows through a designed system in a defined geographic space during a certain period of time. [KOHLER 03] The flow quantities are averaged over a period of typically one year, and the flow directions are tracked from where they are extracted from nature, through their use and then back to nature. The nature to nature flow thus becomes a cycle over time, and reflects a more cyclic view of urban development and operations than the traditional resource to waste models. MFA is a form of systems analysis where the focus is on understanding the system dynamics, rather than evaluating impacts. However the flows can be converted to money or emissions where relevant, to provide an average lifecycle rate of flow. [BOUMAN 2000]

When MFA is applied at the scale of urban regions, the result is often referred to as a metabolic model. The consumption of natural resources by regions is directly analogous to the metabolism of an organism, where flows of biotic and abiotic mass and energy (food and wastes) maintain life. [WOLMAN 65] [WHITE 94] [DECKER 2000]. In their classic text on *The Metabolism of the Anthroposphere* Peter Baccini and Paul Brunner argue that metabolic modeling is the only simple and clear way to manage a transition to sustainable resource use and to avoid exceeding the capacity of the biosphere. By valuing activities, goods and processes in the common currency of material fluxes, it becomes possible to measure and portray the performance of the entire system. The material balances can be converted into energy and money flows, for a balanced and consistent set of accounts. They conclude that, "from an operational point of view, metabolic processes in the anthroposphere must be controlled by the region, a geographically, economically and politically defined entity." [BACCINI 91]

The first application of metabolic modeling to urban areas was a study of a hypothetical American city by Abel Woman, who used population and Input Output statistics to quantify the flows related to urban environmental issues of the time: air quality, water availability, sewage and water pollution. This approach helped to provide people with a systems perspective, in which resources are transformed into wastes, as opposed to consumed. Wolman's MFA results also underlined the potential for improved management of resources by local authorities, since many resources in developed urban regions are simply ignored or wasted, and not actually in short supply. Wolman's work provided an interesting comparison to a subsequent study of the ecology of Hong Kong, by Stephen Boyden and a team of international researchers. Between 1974 and 1981 Boyden et.al. analysed the flows of energy, nutrients and water supply in this rapidly growing urban region.

Metabolic models can be generated at varying scales and locations, and then compared. For example, by comparing human lifestyles from prehistory to present day, it becomes apparent that the volume of metabolic flows is rapidly increasing, and that humanity has gradually accumulated an urban 'corpus' – the long-lasting, stored material resources referred to as the built environment. (Figure 31)

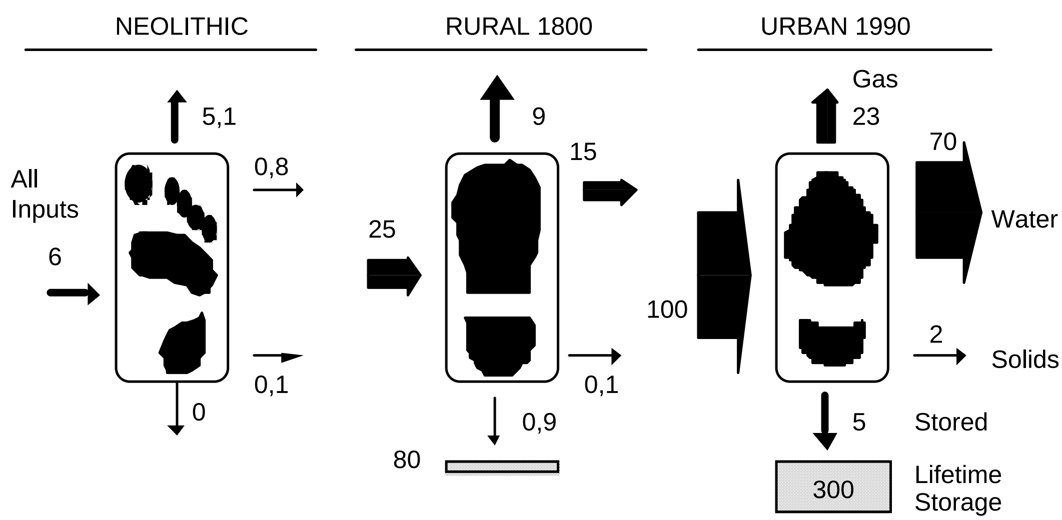


Figure 31 Material flow analysis displays directions and quantities of material for an individual human from the Neolithic to present day (tons per year) [DECKER 2000]

The metabolic flows for different urban societies vary greatly, as do the associated impacts. In European industrialised countries the input mass flow for a typical community can reach 10 t per person year, and the energy required to operate this metabolism (heating, lighting, ventilating, etc.) is approximately 200 GJ per person year – or about half the entire energy budget.

From an analytical or environmental accounting perspective, MFA can be described as a 'top down' model since the data typically begins with aggregate quantities – established by industry and utility records or the government Input/Output accounts, and then statistically allocates the input flows into the various end destinations. LCA, on the other hand, can be described as a hybrid approach, using bottom up modeling to estimate the demands created by various functional units like buildings and roads, and then moves up the supply chain, or downstream to the end of life using default values often obtained from input/output statistics. Figure 32 illustrates the differences between top down and bottom up for all scales.

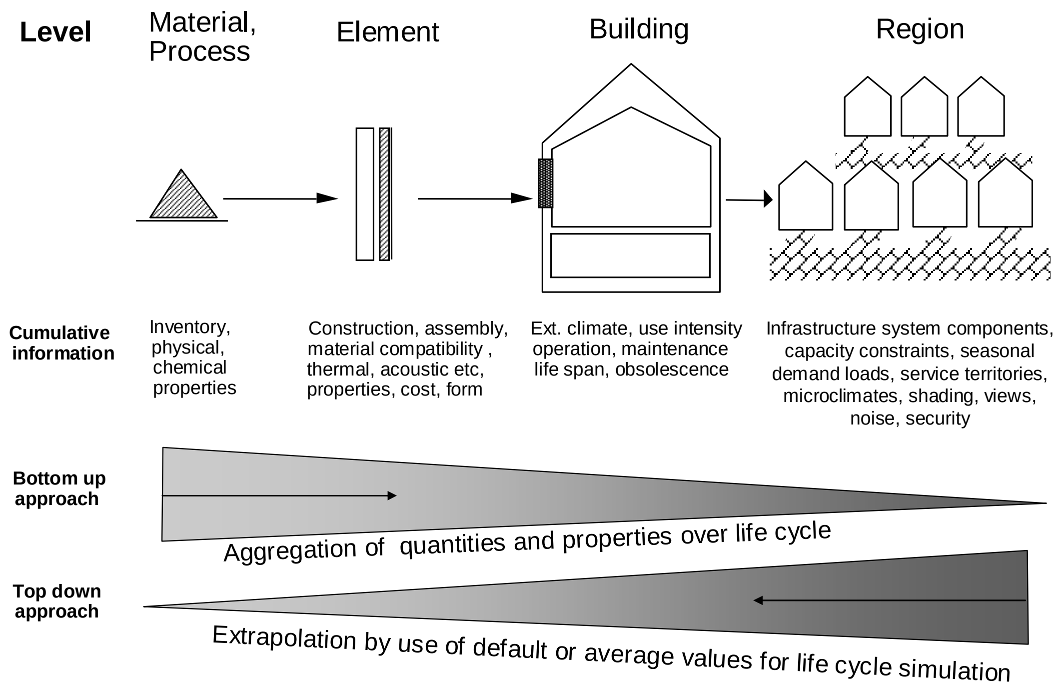


Figure 32 Both top down and bottom up approaches can be used to generate aggregate values for building stocks and urban infrastructure

Metabolic models are especially useful when exploring improvement strategies and pathways for sustainable development. The models promote a systems perspective, and focus attention on those areas of production and demand that are most relevant to the region's goals and targets. The time frame is not based on the product life cycle since the entire urban system is potentially an eternal artefact; instead the time scale is usually set arbitrarily to reflect one year of operation for each stage in the lifecycle. Types of products, lifecycle stages, or uses do not limit the MFA flows; instead the flow limit is set by the geographic boundary (e.g. the region) and the resource flow in question. The data collection process is not rooted in the LCA databases for commodities and products; instead the calculations begin with the total receipts or sales recorded by utilities involved with supply of resources (from nature) or with disposal (to nature).

The LCA method provides a detailed and verifiable basis for quantities based upon demand. The MFA provides a verifiable basis for quantities at the whole system scale. By using MFA to calibrate the LCA aggregations, the model gains rigour without loss of resolution [KOHLER 99]. By using LCA to estimate the upcoming costs associated with recurring investments, the model can achieve accurate forecasting of flows.

Sankey Diagrams and Metabolic LCA

Sankey diagrams have been used to visualise period-oriented material and energy flow models. A Sankey is a directional flow diagram with balanced inputs and outputs. It typically shows flow quantities, and can be used to portray inventory data, system dynamics, ecobalances, and eco-efficiency indicators. [MOELLER 02] [WHITE 94] Sankey diagrams are named after the originator who first applied the method in the mid 1800s.

Typically, a Sankey reflects the substances and processes of concern to specific decisions, at a resolution appropriate to users. Some Sankeys move horizontally, some vertically. Some display just two partitions, others many. Some show all types of energy or material flows, others only subsets. Some show 'nature-to-nature' flows - reflecting the full urban metabolism. Others show only the flows of direct interest to infrastructure engineers. Energy Sankeys, for example, tend to show waste heat as a by-product (dropping off the chart perpendicular to the other flows), or to lump waste into the same level as end-use demands.

Sankey diagrams can represent period-oriented MFA, presenting flows in the same balanced accounting as corporate finances. The length of the period can vary depending upon the decision-making. If flows are averaged over the year, they provide a good benchmark for tracking efficiency and for understanding ecological footprints. However annual flows fail to reveal the seasonal and daily peaks, which impact costs, and are often a key determinant in system design. Ratio of peak to average can range from 2 to 10 for such flows as energy, water and people in large urban centres. A Sankey based upon peak hour for energy in the peak month, or for daily flows for water during the driest month, provides an especially important perspective from which to evaluate a system design alternatives. Different connections, and different types of supply, can alter system capacity at these critical times.

One of the first and best known Sankey diagrams is the Minout graphic that portrays Napoleon's army marching to Moscow, shown in Figure 33. Interestingly, this Sankey visually displays the distances travelled, the itinerary or locations visited at specific times along the route, both to Moscow and back home, and the number of troops in the different parties at each stage and time. As Edward Tufte points out in his book on *Envisioning Information*, this single graphic portrays six layers of information. [TUFTE 90] With the possible exception of recent flow charts used for systems engineering software, it is probably impossible to find a graphical technique that can convey so much information on a single page to so many types of people.

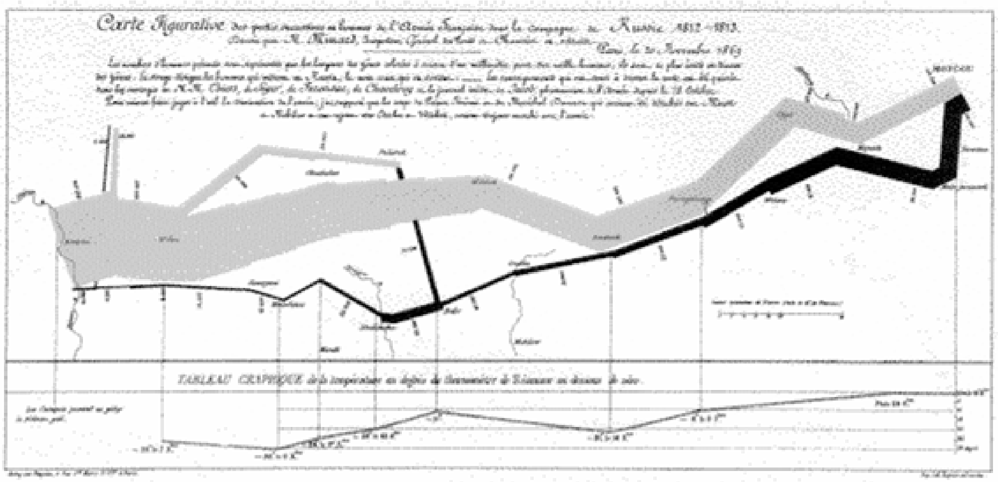


Figure 33 A 19th century Sankey diagram of Napoleon's march on Moscow communicates on a single graphic many layers of information including quantity of soldiers marching in each direction by location and time

In the late 1970s Boyden used Sankeys to illustrate the dynamics of Hong Kong's urban metabolism. Figure 34 is an example of the water system flows. In 1980s and 90s the rising concern over sustainable development and whole-system performance resulted in more people using Sankeys diagrams for describing systems and comparing development scenarios. Two types of Sankeys predominated in urban regional studies: energy Sankeys and MFA Sankeys. Energy Sankeys help to show the 'full fuel chain', which is important because the capture and conversion of energy often represents a sizable portion of the total life cycle consumption. Energy Sankeys also help to emphasise how the majority of energy is waste heat, and how current systems fail to cascade energy through multiple uses. MFA Sankeys tend to focus on whatever issue is of concern within a region.

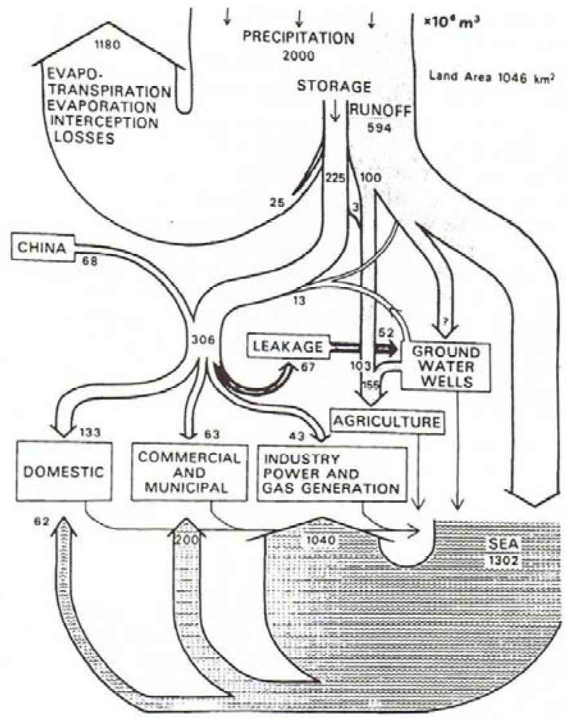


Figure 34 One of the first Sankey diagrams for urban systems successfully summarises the quantities, flows, directions and uses for all water flows in Hong Kong [BOYDEN 81]

Combined energy and MFA Sankeys have been used extensively in Switzerland as part of a multi-partner research project –SYNOIKOS – which investigated the long-term restructuring of a region in the Swiss Lowlands in view of sustainable development. Figure 35 shows two scenarios for energy and gravel flows through an urban region in the Swiss Lowlands. [BACCINI 98] Note that in all these modern Sankeys, the geographical information associated with any process – which formed an important element in the famous Minout example – has been lost.

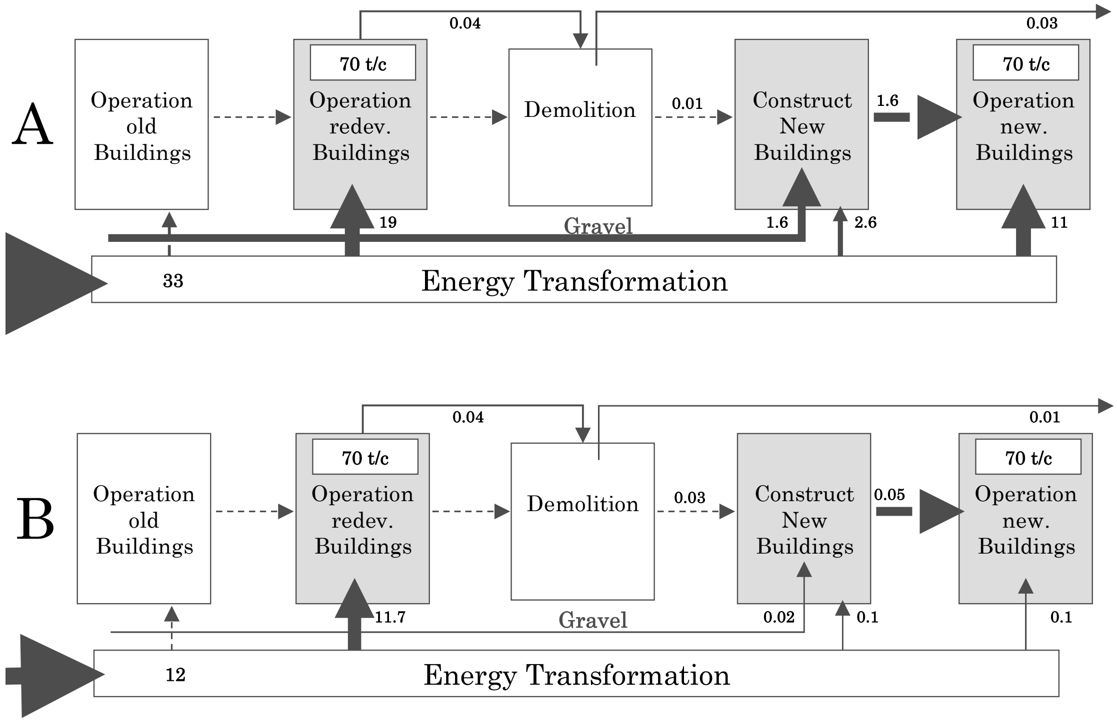


Figure 35 Two scenarios for material and energy flows for residential buildings in 2050 in Swiss Lowlands with energy in GJ per capita year and gravel fluxes in tons per capita year [BACCINI 98]

When Sankeys are used as an environmental accounting system, the substance will generally comprise a subset of the energy and material flows. The subset can be specific types or categories of chemicals, materials, energy, water, or even people. Such flows can also be converted into equivalent units of emissions, money, or information.

Whatever the substance flowing, a Sankey diagram is comprised of partitions, nodes, edges and arrows. (Figure 36) A partition represents the transitions or stages within the flow where transformations may occur, and thus are similar to the transitions in Petri Nets; any Sankey must have at least 2 partitions to create possibilities for a flow. [REISIG 85] The nodes are the divisions within a partition; they represent processes or events that regulate or transform the quality of flows. Edges are the paths (or noodles) that emerge from nodes and that direct flows to nodes on the next partition. The width of the edges is proportional to the flow quantity. Arrows indicate flow direction.

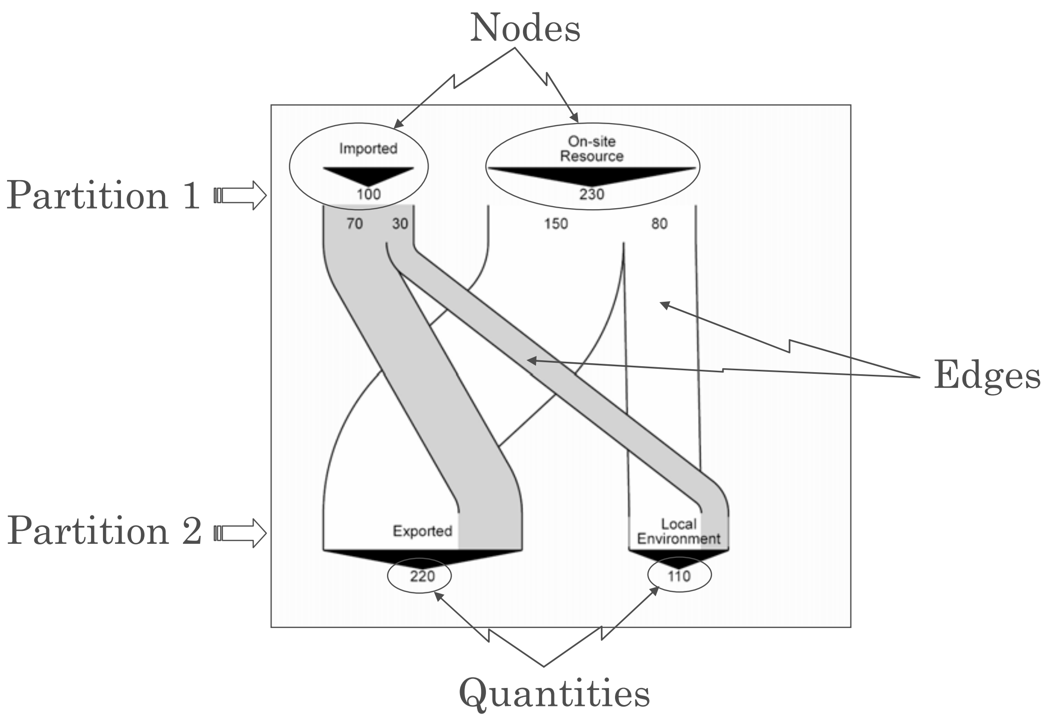


Figure 36 A Sankey diagram is composed of at least two partitions, and multiple nodes, edges and quantities

As a period-oriented graphic the Sankey diagram is a unique method for communicating longer-term lifecycle perspectives with the shorter-term system dynamics. By combining a series of Sankeys it becomes possible to illustrate changes within a system at different time periods in the day or season, or at different years in the past or future. In this way the Sankey may be a tool both for communicating system dynamics over time, and illustrating scenarios for urban system design. [WHITE 94]

The weakness of Sankeys is the lack of any standardised formats and structure, without which it becomes difficult to compare one scenario to another, or one location to another. As Decker and his colleagues point out in their review of urban metabolic studies, there is a real lack in cross-cutting compilations, field research and integrated modelling. [DECKER 2000] Also it is difficult to combine flows of energy and mass in a single Sankey without loosing the systems view. Finally the variation of flows over time – peak loads for example – require multiple Sankeys.

4.3 The Essentials

Decision Support Systems appear to be especially important as a way to cope with the added complexity encountered when design occurs that the scale of urban regions and within the context of sustainability.

A very wide range of generic tools and methods already exist for addressing time concepts, ranging from narratives to sophisticated computer modelling. However the history of DSS within design practice is not especially encouraging. Few tools are used regularly in urban system design. A number of tools exist for time extensions, although their functions are not always clear. Time cycles are also addressed to some degree –through S-curves and LCA – but their use in system design is extremely limited. No tools appear to deal well with system interactions over time (the time rings) or with changes in time preference (e.g. ecological constraints).

LCA and metabolic models are especially powerful methods that have evolved within the research community and that now appear to be ready for wider use within design practice. Potential for such methods can be increased through scalability, standardisation and the use of innovative visualisation techniques like Sankey diagrams.

DSS for sustainable urban system design must be flexible and transparent. Outputs must be matched to the needs of users at each stage of design, and to the particulars of the design project.. The full suite of tools may be needed to address new time concepts. In the later half of this thesis special attention will be given to how DSS tools can be modified to better match the requirements of sustainable urban system design.

PART 2: TIME FOR DESIGN

The time dimension is so pervasive and penetrates the social fabric so deeply that the findings of many disciplines in the human sciences must be utilized.

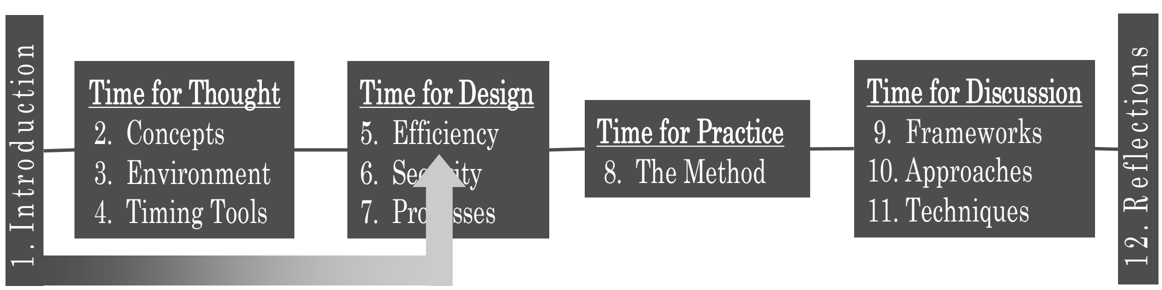
Alexander Smith 1988

5 How Might Time Concepts Affect System Efficiency?

Improving system efficiency is essential for many urban regions if they are to live within environmental limits, and achieve economic prosperity and social justice over the long-term. Efficiency is perhaps the principle design solution for achieving sustainability. From the perspective of urban regions, the challenge is not only to improve the efficiency of individual processes, but of course to find among the many different elements positive synergies – elegant design solutions that achieve multiple objectives simultaneously.

One way to approach long-term system design is to examine successful living systems. Successful ecosystems provide working examples of long-term system design, and as such provide three services: (1) a heuristic for how to manage complex relationships and the dynamics of change and adaptation; (2) a library of design successes and failures from which we can learn to innovate; and (3) a model for deriving fundamental principles of sustainable design practice. Ecologies thus represent both a conceptual tool kit and a philosophical alternative to the short-termism of post-modern design practice.

This chapter will explore what is involved in achieving system efficiency and positive synergies at the regional scale. The focus will be on how new time concepts might enable such work. In particular, do extended time horizons make it possible to better organise land uses and connections, and optimise the mix and diversity of activities? To what degree is it possible to transfer long-lasting design solutions from successful natural systems to urban systems? Does ecological design represent a philosophical alternative to the time concepts of post-modern design practice?



5.1 Where are the Synergies in Urban Systems?

While the concept of intelligent, integrated design applies equally to all infrastructure, historically such approaches have been limited to transportation infrastructure, where long-term system design is seen as a possible antidote to the rule of automobiles. As Jane Jacobs pointed out in her first critique of the modern city plan: "Automobiles are often tagged as the villains responsible for the ills of cities. But the destructive effects of automobiles are much less a cause than a symptom of our incompetence at city building." [JACOBS 61]

In North America, an integrated, design-based solution to transportation infrastructure is commonly known as 'Smart Growth', a programme that is promoted by extensive literature and numerous organisations across the continent.[13] Smart Growth is about combating urban sprawl by designing distinct, mixed-use, walkable, compact and 'complete' communities that reduce the demand for frequent, long trips. Housing density is increased close to work, school, shopping and transit, where possible within the existing urban fabric. A mixing and layering of land uses enhances diversity and convenience, and also attempts to balance the availability of affordable housing with the income level and number of local employment opportunities.

Although Smart Growth has received many endorsements from opinion leaders, and is promoted widely in Canada and USA, it still represents only a very small fraction of development projects. The surprising low penetration is now the focus of housing research agencies. CMHC Housing Research attributes the failure to a lack of political will at all levels: regulations that mitigate against innovation; lack of interest within the development community in anything unconventional; financial impacts of local taxation and charges, and a persistent consumer preference for lower density landscapes. [CMHC 05] Other studies suggest that even when penetration rates are high the only significant benefit from Smart Growth is that residents tend to walk more and therefore stay healthier. The expected reduction in automobile use from smaller commutes, closer transit, and walkable services, is compensated by more recreational travel.

Some studies have indicated that only a small proportion of people actually consider slow modes of transportation, and that the relationship between land use and trip generation and trip distances is a difficult mix of factors including cultural bias, demographics, safety, time costs, health and recreation needs, the quality of regional amenities, and so on. In Austin, Texas, a survey of alternative neighbourhoods indicated that the average resident liked to shop at 8 grocery stores in a week, choosing one for its special ambience or another for choice in products, and thus locating residences near a single grocery store may be insignificant. [HANDY 03]

Part of the difficulty with application of Smart Growth principles is the short-term decision frameworks used by consumers, investors and public agencies. The land use and infrastructure changes require decades to mature and impact the choices people make about where to live and how to travel, and thus it is

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[13] List of groups and resources available at: http://www.smartgrowthamerica.org/resources.html ; accessed July 06

difficult to establish cause and effect models to justify new approaches. However it is also possible that the models are failing to properly convey the long-term advantages in ways that can assist decision-makers in making the right choices, especially in the face of opposing interests. A number of cities are now using urban modeling tools like INDEX and QUEST and INFRACYCLE to develop an economic rationale and compelling storyline for smart growth design and policy. [NRC 05]

Design-based solutions for non-people flows – energy, water, materials, information – can typically benefit from the same basic design strategies as promoted by Smart Growth, although the practices are known under different names or philosophies. The best known approach to the design of intelligent energy and materials systems is referred to as 'industrial ecology', an application that attempts to arrange the mixture and proximity of industrial processes to facilitate local looping and cascading of flows. The wastes from one process become the inputs to another, (a constructed food web). Often industrial ecology design will integrate industrial process flows with the flows through the surrounding residential and commercial sectors to create, in essence, a municipal ecology.[14] The progression towards municipal ecologies makes sense, since the greater mixture of process can only increase opportunities for more efficiency and stability. However the impediment to the emergence of municipal ecology is the lack of skill within the urban design community, and the lack of a mandate for planning and designing the region as a metabolism.

5.2 Can Ecological Design Principles Guide System Design for Urban Regions?

5.2.1 From Industrial Engineering to Ecological Design

An ecological system is a natural, self-regulating community of plants and animals that is sustained by solar energy and that is adapted to a set of geophysical and climatic conditions. Ecological design transfers design principles and design solutions from ecological systems to constructed environments. The approach emerged slowly over a period four decades, and represents an alternative to industrial engineering.

Industrial engineering created the coal age cities of western Europe and North America, and was an appropriate design method in an era of extreme poverty

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[14] The most cited example is Kalundborg, Denmark, where a coal-fired power plant sends waste heat to housing, greenhouses and other industries, and sends its ash for conversion to building materials. It also exchanges fuel, heat and water with an oil refinery, chemicals and pharmaceutical works. [ ]

and rapid economic growth. In the 19th century, urban systems needed to be universal and expedient. Beginning with the provision of potable water to houses in London in the 1830s, the design process was driven by a civic leaders, social reformers and visionary engineers. J.B. White, writing in 1870 in *The Design of Sewers and Sewage Treatment Works,* claimed that better sewers were the solution to avoiding the periodic plagues that had destroyed so many cities and engendered so much suffering through the course of human history. [WHITE 1870] Thus plumbing became the first in a series of utopian solutions based upon providing urban residents with critical infrastructure systems. To achieve economies of scale, the system components were standardised and facilities were centralized. Typically each service – water, waste water, solid waste, town gas, electricity, street cars - had a separate administration, focused on rapid expansion. The result was a massive growth of centralised, single-purpose infrastructure systems, and a corresponding massive improvement in quality of life for the urban populations.

Beginning as a response to environmental regulations in the 1960s and70s the design philosophy for basic infrastructure services expanded to include 'environmental engineering' (initially referred to as sanitary engineering). This new focus addressed externalities by means of 'end-of-pipe' systems for waste control, treatment and disposal. Although the concept of ecological engineering was also introduced in energy terms during the early 60s by H.T. Odum, [ODUM 63] the concept did not become well understood in practice until the late 1980s. Even now there tends to be some confusion around the scope of what may be included. All approaches to ecological engineering use quantitative, science-based design methods, and employ organic ecosystems to remove, transform or contain pollutants. The level of human intervention may vary depending upon cultural and professional factors. In writing about *Ecological Engineering: The Roots and Rational of the A New Ecological Paradigm*, William Mitsch contrasts different approaches, and argues that the essential components include the use of self-organizing ecosystems (where humans merely provide the initial choice), self sustaining ecosystems (where humans provide little or no non-renewable energy inputs), and a whole systems approach. [MITSCH 97]

By using natural systems to clean and regulate flows it is possible to save capital and operating costs relative to constructed systems, and provide multiple ancillary benefits. More specifically it is possible to control and improve flows of air, particles, water, and organic waste through the use of shade trees, greenways, wind breaks, compost bins, reed beds, community gardens, riparian strips, ponds, salt-water marshes and constructed wetlands. At the same time these natural systems may provide recreation, views, climate control, species habitat, food production, and carbon absorption.

If ecological engineering is designing with nature, the next shift in paradigms is designing 'like' nature. A number of seminal articles in the early 90s outlined a new approach to urban design, building upon the ecological theories developed by pioneers like Eugene Odum. [ODUM 89] [BRUGMANN 92] [VAN DER RYN 96] [THOMPSON 97] [STITT 99] [KOH 05] By the late 90s these concepts had coalesced into a renewed approach to landscape architecture, that reconnects with the ecological roots of the early regional planning movement.

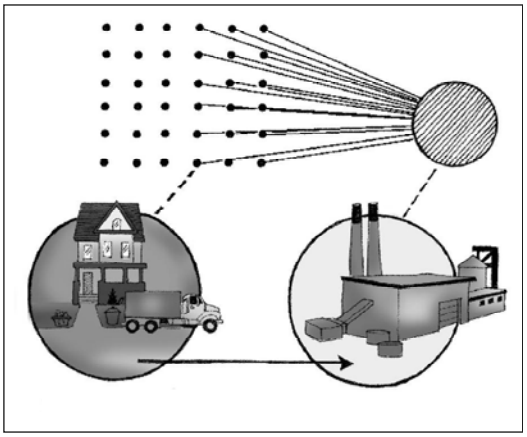
In essence, from ecological systems we distil a set of principles that are then applied to design projects at scales from the building to the urban region. Brugmann focuses on the principles of integration, elegance, recycling, functionality, adaptability, diversity, synergy, carrying capacity, and feedback. Koh describes many of the same ecological design tools, but focuses on three over-riding principles: inclusive unity, creative balance, and complementarity. Bunyan, in her philosophy of 'bio-mimicry', applies the concept of ecological design at all scales from manufacturing to agriculture, computers and urban design. "In a biomimetic world, we would manufacture the way animals do, using the sun and simple compounds to produce totally biodegradable fibres, ceramics, plastics and chemicals. …. In each case nature would provide the models: solar cells copied from leaves, steely fibres woven spider-style, shatterproof ceramics drawn from mother-of-pearl, cancer cures compliments of chimpanzees, perennial grains inspired by tallgrass, computers that signal like cells, and a closed-loop economy that takes its lessons from redwoods, coral reefs, and oak-hickory forests." [BUNYAN 2000]

In all cases the principles of ecological design provide a rich pallet for systems design, based on natural precedents. Koh argues that the science of ecology provides a basis for post-modern landscape architecture because it reintroduces to aesthetics a measure of constraint and a sense of morality. [KOH 05] He points out that ecology is a science fundamentally about intelligent, self-organising (syntropic) systems, which makes it the most appropriate science for guiding urban design. Rahul Mehrotra makes a similar argument: "Urban design is not 'big' architecture - or even city design. Rather it is a perspective on stewardship of landscape that integrates social and ecological values into design." It is a process where a mix of cultures and professionals become custodians and creators of environment as a whole. [MEHOTRA 06]

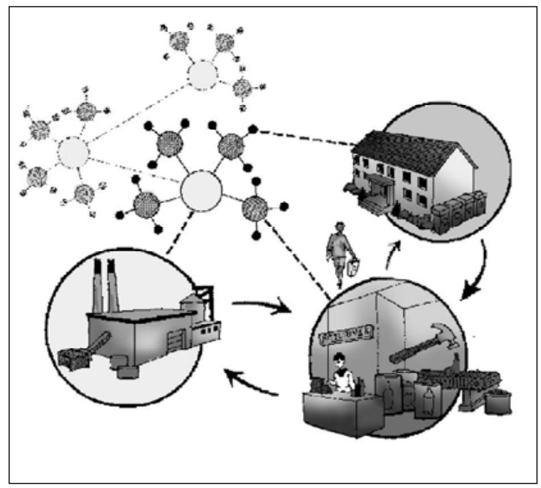
Ecological design is a living version of David Atkinson's futuristic political ecology discussed in Chapter 2. In essence a new aesthetic of ecological design emerges based upon a less conflictual relationship between human beings, and between nature and society. It adopts the classical notion, embodied in vernacular culture, wherein the ethical is subsumed into the aesthetic. [ATKINSON 91]

System Efficiency

Ecological systems provide many examples for designers to achieve more efficient and sustainable systems. For example we can use nature to explore how best to integrate the morphological and physiological nodes in Baccini's Netzstadt model. A natural solution is to transform urban systems from hierarchical, one-way through-put systems into cellular networks where specialised cells serve each other, and serve the regional system as a whole, through a matrix of in two-way flows. (Figure 37)



Remote & Isolated Solid Waste Management, circa 2000



Clustered Solid Waste Management, circa 2050

Figure 37 Traditional infrastructure design may evolve into cluster structures, with nodes and networks of two-way flows for waste, energy, water, information and so on.

In ecological design the quality of resource is closely matched to the requirements of the end use – or niche, allowing energy, water and materials – or nutrients - to cascade through a complex food web - or urban metabolism. (Figure 38)

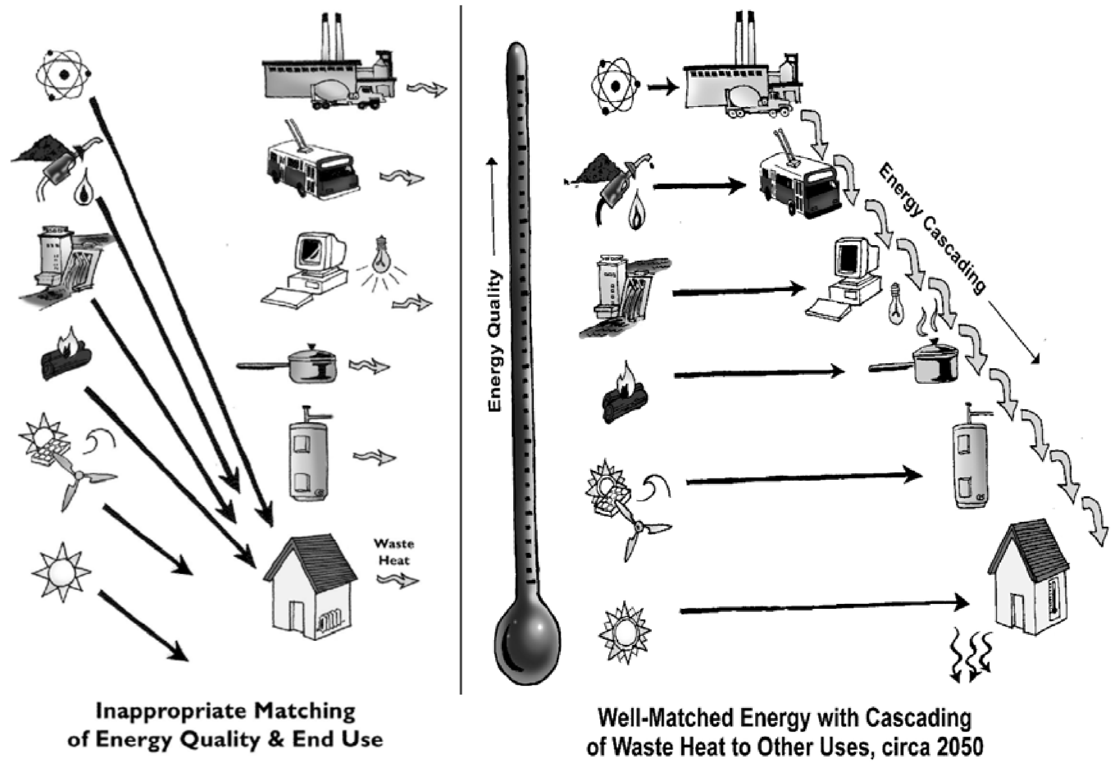


Figure 38 Ecological designs allow for energy and materials to cascade through a food web where the quality is well matched to the requirements at each niche

Nested networks share information and then give and take according to their own needs and the demands of the region. Functionality is localised and often integrated into elements of buildings, neighbourhoods and surrounding natural systems. Multi-purpose elements serve many separate infrastructure systems, so that the end result is a single, undifferentiated system. (Figure 39)

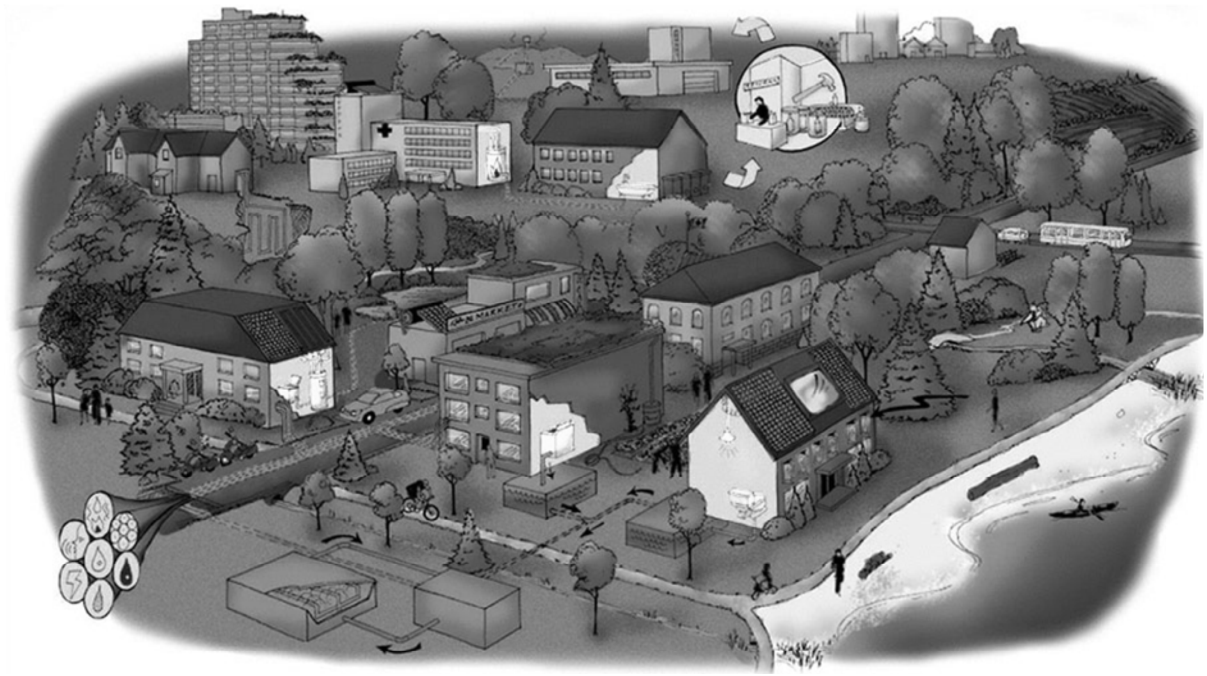


Figure 39 Cluster structures for all systems may blend into an undifferentiated urban ecology: distributed, interconnected, integrated, adaptable, low-impact, service oriented, self-organising and multi-purpose.

A Japanese design team working on the Mishima 2100 Sustainable Urban System Design submission extended the cellular concept of urban systems to include the identification of alternative functions in cells. [ITOH 03] Resource production cells and green cells serve the more social cells (Figure 40). The evolution of specialised neighbourhood cells is achieved over time by stimulating the natural tendencies of existing neighbourhoods – a process described as urban acupuncture.

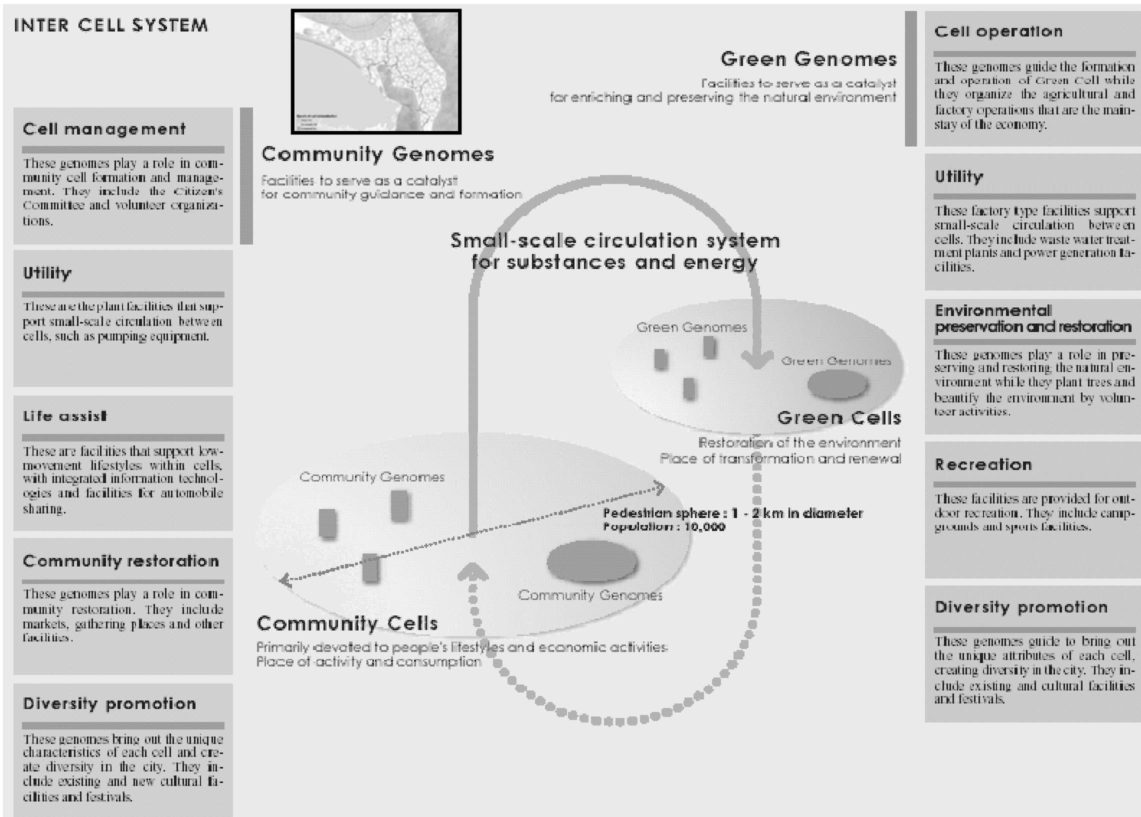


Figure 40 Cellular models for urban ecologies are becoming a long-term design heuristic, as shown in the Inter Cell System for Mishima City, Japan, where neighbourhoods are designed to specialise in complementary functions [ITOH 03]

More diverse land use and building types complement the on-site infrastructure systems by smoothing and levelling the demand for services, and by creating opportunities for re-use and synergy. Urban clusters become more diverse and self-reliant, with mixtures of housing, commercial space and industry. In the process, the traditional parcelling of land uses, and isolation of industry and infrastructure gives way to a multi-layered approach. Extending the concept of ecological engineering, designers will literally wrap houses and offices around the industrial and infrastructure systems, as these critical elements become a local and diverse source of warmth, water, food and diverse employment. [MOFFATT 2000]

An example of how ecological design paradigms evolved for urban systems

Storm water management in Greater Vancouver provides an chronological example of the changing mind set for infrastructure design.

Industrial engineering, in the late 1800s, used culverts and pipes, burying the many streams that interlaced the landscape, and collecting the storm run-off water into the same pipes that were being installed to handle the sewage flow.

The result was a combined sewer system that still exists in the core neighbourhoods of Vancouver, similar to cities everywhere at that time. The reed beds and mud flats around the shoreline were in-filled for industries that used water for transportation, cooling, and waste disposal. Larger wetlands were drained by Dutch immigrants and converted into farms, dykes and roads.

Environmental engineering in the 1970s, required that large urban centres provide secondary treatment, leading to construction of end-of-pipe treatment facilities at significant cost. Even with the new plants, the combined sewerage system created two kinds of problems. Firstly the heavy storm events created so much water flow that they had to be diverted, leading to direct dumping of both the storm water and sewage into False Creek and other water bodies around Vancouver. Secondly the extra flow in the pipes during the long rainy periods added substantially to the treatment costs. As a consequence Vancouver and the surrounding municipalities changed the engineering standards and required two pipe systems, one for storm and the other for sewage. In some low-lying areas the residential regulations required roof run-off to be stored in underground sump pits, to alleviate the peak flows. However problems persisted. In higher locations – the urban reserve lands – new subdivisions replaced the traditional forest cover. Increased run-off into surrounding agricultural lands led to long wet periods in spring, preventing farmers from planting their crops in time. The higher flows into the remaining streams and rivers created erosion, turbidity, higher temperatures and ultimately a loss of fish habitat and the decline of the salmon stocks and fishing industry revenues. High flows also required new and higher dykes and berms.

Ecological Engineering in the 1990s, used constructed wetlands and attenuation ponds to reduce storm water transit and treatment requirements. Water catchment areas were protected by laws. Flood plains were excluded from the core growth concentration areas. All of the old stream courses were mapped, some were marked with plaques, others were 'day-lighted' and salmon reintroduced. A sustainability vision developed for the brown field sites in Vancouver's downtown waterfront proposed to recreate the original length of streams, and use riparian strips to clean and regulate the water and in so doing, bring back the herring spawn to the False Creek waters. [SHELTAIR 97] Neighbourhood associations began to propose on-site tertiary treatment of sewage in greenhouses and gravel systems, on an experimental basis. The foreshore areas of the refurbished waterfront were designed, in some cases, as naturalised reed beds.

Ecological Design began to emerge by the turn of the century, as a number of neighbourhood developments in Greater Vancouver began to address storm water at all scales and locations. Allowing water to rapidly flow off site seen as an energy loss (entropy) with many externalities. The key object was to protect fish habitat in streams – the nursery of the important west coast salmon ecology – by reducing peak flow events or exceedences, and by keeping the erosion, heating and turbidity of run-off within traditional limits. A landmark project on Burnaby Mountain – where housing for 10,000 people was to be provided next to Simon Fraser University – established design guidelines that could be used on almost any site with a mixed residential and commercial development. The targets for the site included the goal of no significant change in the quantity and quality of water leaving the site relative to predevelopment flows. Base monitoring of the water run-off began prior to any site development. In essence the constructed environment was designed so as to function similarly to a forest, in terms of the water flows leaving the site. This was accomplished by means of a cascading series of design innovations, from the scale of buildings to the scale of the whole site. The key strategy was to slow and cool the water though sub-surface flow. Design features also included cisterns for buildings, increased use of trees in the landscape, more green and permeable surface treatments, infiltration trenches in place of pipes along roadways and paths, swales and detention wet or dry ponds, and the selective retention of hedgerows and forest strips alongside existing stream courses. Schoolyard games fields function as temporary detention ponds in extreme storm events.

5.2.2 From Ecological to Evolutionary Design

Extending time horizons at the regional scale may permit a further evolution in the practice of ecological design, towards evolutionary design strategies such as succession, adaptability and alternative functionality. Such strategies may help designers and planners manage the slow pace of landscape transition (the outside of the time rings).

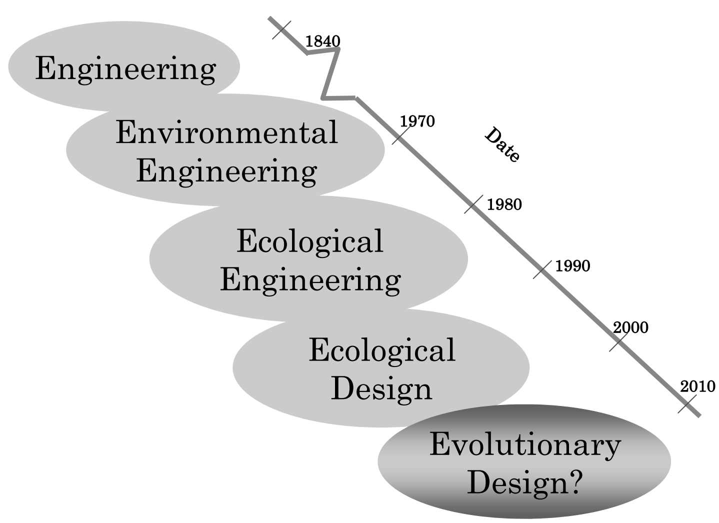


Figure 41 The application of longer-term time horizons, at a regional scale, allows a further progression in ecological design theory

Long-term change management is seldom considered when designing green building projects. Typically a fine scale and a virgin site help design teams achieve their performance goals almost instantly. The design of urban systems, however, is much more likely to benefit from a progressive strategy that moves the existing built elements through stages that reflect a more natural pace of change. Taking a thermal energy plant off-line, for example, cannot happen without residential demand management, and this implies a relatively slow process of working with multiple property owners and renovation cycles. Thus long-lived elements may set the pace for changes in the system as a whole. The ecological design approach thus implies a design strategy based upon succession within built systems.

Succession is a term that refers to "the non-seasonal, directional and continuous pattern of colonization and extinction on a site by species populations". [BEGON 90] Succession is different from random fluctuations in community structure because there is directionality, with species mix following an orderly progression – or 'sere'. The progression can be part of a cycle that repeats at different scales. A tree falling in a forest creates a mini-clearing, which becomes an opportunity for a mini-succession despite the forest overall having reached the final seral stage – a climax community. Succession is sometimes categorized into primary succession – where the first stage is the colonization of newly exposed land forms, and secondary succession – where the first stage is a disturbed site that nevertheless contains well developed soil, seeds and spores. In reality such distinctions can be misleading, since all seral stages occur along a continuum from bare ground to complex biotic interactions among existing species at a site. As the environment and climate vary, even the climax old-growth community must slowly equilibrate with the prevailing disturbance regime. Thus all stages can be seen as in flux.

The ability of some organisms to initially colonize and regenerate a site is an important pre-requisite for succession. Given enough time, succession converges on a stable species composition which is independent of the initial composition of the forest or woodland / grassland / shrubland. The outcome is inevitable and depends only on the fact that adjacent areas provide a source of seeds not initially present. Temporal scales for a complete succession can be long and the process is subject to high uncertainty. In theory an old-field succession may require 100 to 300 years to reach climax community. In reality, the probability is high that over such long periods the field will experience physical disturbance such as fire, hurricane, drought or flood. For this reason the seral stages may never reach completion, and cycling becomes the constant pattern. Thus succession may be an ecological version of the cyclical, progressive, and fractal 'sustainable time concept' envisioned in Chapter 2 of this thesis.

Progression over time is influenced by at least three dynamics: facilitation, tolerance and inhibition. Facilitation occurs when one species mix creates an environment – more soil, more shade, more moisture - that allows other species to become established and to out-compete the original community. Tolerance occurs when the changing conditions are better tolerated by some species, and thus they survive and ultimately replace the original mix. Inhibition occurs when the original species mix is designed to prevent any progression, and thus hangs on until an external force – e.g. flood – creates opportunity for later species to gain a foothold.

Succession commonly, but not always, leads to a greater amount of biomass on a site. Under some conditions the succession can fail to ever reach climax because the resources are fully metabolised and mineralised as a result of a run-away pest such as the pine beetle destroying entire forests. 'Degradation succession" also can occur, with one set of organisms leading to another, as the dead organic matter is slowly mined for resources and eventually degraded into much less value.

These succession dynamics may help to guide strategic design for urban systems. Brugmann argues that the concept of ecological succession can be used to directly explain the current crisis of urban sustainability. [BRUGMANN 92] From a long view, the industrial urban ecosystems are undergoing many of the same kinds of transformation exhibited within nature as young ecosystems transition to a mature climax stage. Young natural ecosystems exhibit common development stages. [ODUM 89] Energy (or nutrient) invested in primary production of biomass exceeds the amount of energy invested in the maintenance of the system. Net community production or yield is relatively large when compared with the same system in its mature of climax stage. In order to achieve such growth rates, nutrient cycles are open, and the exchange of nutrients and energy between organisms in the system is very rapid. Food chains and food webs are very simple. Species diversity and biochemistry diversity are low. Systems are relatively simple, and thus resource efficiency and stability in the system is low.

A mature ecosystem is much different. Although the size (or biomass) of a mature system is larger, production rates are lower than a young ecosystem. Energy and nutrients are more heavily invested in system maintenance than in production. The emphasis is on quality rather than quality. Cycles become closed and the role of waste material as a nutrient source becomes more important. Food webs or resource exchange networks become very complex. Diversity increases, as does specialization of function and efficiency of resource use. Information flows play an increasingly important role, as the system becomes more cybernetic and resilient. Thus the differences between young and mature ecosystems becomes a metaphor for 21st century urban system design.

Part of the ecological solution is to grant value to the slower moving parts of the system. Odum describes natural succession as a protective strategy, since accumulated organic structure, stored nutrients and diversity in the landscape are a hedge against unfavourable times. The most pleasant and safest landscape – natural or constructed – is a mixture of communities of different ecological ages: productive and protective. [ODUM 89] Holling also emphasises the importance of stored resources and natural capital as a form of resilience. [GUNDERSON]

New urban design is currently based on a 'productive strategy' which develops and maintains early successional types of ecosystem that turn over materials quickly, often at their peak of growth, leaving little to protect the landscape from weather, wastes, and other uncertainties. It is important to examine older, survivor communities to understand the progress towards a climax sere for constructed environments. In the existing older communities, such progress is especially challenging. The pace of technological change will need to be matched to natural turnover rates for the stocks, as functional integration evolves incrementally – the facilitation model. The performance of the existing systems may need to be forecasted in order to allocate resources between maintenance and refurbishment on the one hand, and whole scale replacement with alternative systems on the other.

In natural ecosystems the growth continues until the maintenance requirements equal the maximum local energy input. For urban systems the energy inputs are no longer local, and in fact are mostly imported as food, fossil fuels and manufactured products. As Decker et al conclude: "If modern urban systems are undergoing some form of succession, it is now at the earth system level. The climax will occur when global energy resources are marginally utilised, energy flux is at a steady state, and infrastructure growth has ceased." [DECKER 2000]

5.2.3 Evolutionary Design and Time Cycles

It is conceivable that a timing model for the urban region might also address the potential for long-term recycling of the urban elements. Such cycling by design has been proposed by the Goa 2100 Team from India as a more ecological and responsible perspective. [GOA 2100] In Figure 42 they have contrasted the conventional linear flow of forest-to-field-to-city-to-wasteland, to a more cyclical and flexible pattern. The implication is that residential areas, and any other parts of a city not dedicated to the trunk lines and hard infrastructure, would be purposefully designed to facilitate an eventual return to nature. No discussion is provided on how policies might be enacted to provide the necessary resources for such a transition. However the precedent exists in the manufacturing world. As Lynch argues, "Obsolete environment, like refuse or scrap cars, is a type of pollution, a cost that should be borne by the stream of users, rather than by the latest heir." [LYNCH 93]

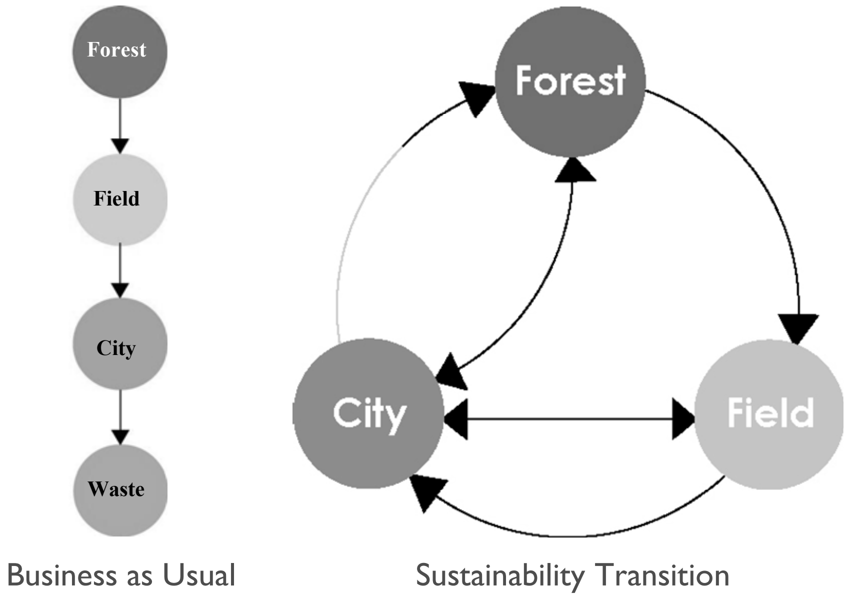


Figure 42 Succession pathways for urban systems, contrasting the current design paradigm with a more cyclical transition [GOA 2100 03]

As a narrative tool, a number of researchers have examined urban systems as they have evolved in different eras and cultures, in a search for patterns that transcend time. Hollinshead argues that cycles of changing energy technology and energy sources over the last 200 years have more than any other factor influenced the form and function of cities, their technology, economies, buildings, transportation, social structures, and quality of life. [HOLLINSHEAD 05] He argues that from the perspective of long view cycles, the most significant urban system is energy. Cities can't exist without access to reliable energy resources, and generally speaking, the more energy available at affordable prices, the greater will be a city's size, complexity and material wealth.

Howard Odum was one of the first to quantify and systemize energy flows in and out of cities, and the corresponding impacts on the environment. [ODUM 71] Energy transformations in cities still account for about 80% of problematic air pollution, and are the source of the most significant urban and global environmental risks. Sustainable development is firstly about keeping these energy flows within the bounds of what the natural world can provide, and the associated waste flows within what the environment can absorb in the long term. [COSTANZA 91]

Nakicenovic has analysed the historical progression of primary energy forms in the US economy over the past 200 years. (Figure 43) Beginning with human food as a primary energy source, we have since moved through wood and hay, coal and oil. [NAKICENOVIC 88] Methane is almost certain to become predominant in the next 15 years – it is already the primary source in most world cities. The nuclear age was clearly online to replace fossil fuels, until the trend line was interrupted by widespread concern over public safety – and then by the ultimate coup de grace of Three Mile Island and Chernobyl. In place of nuclear we can see an exotic mixture of renewables emerging as the predominant source in 30 to 50 years.

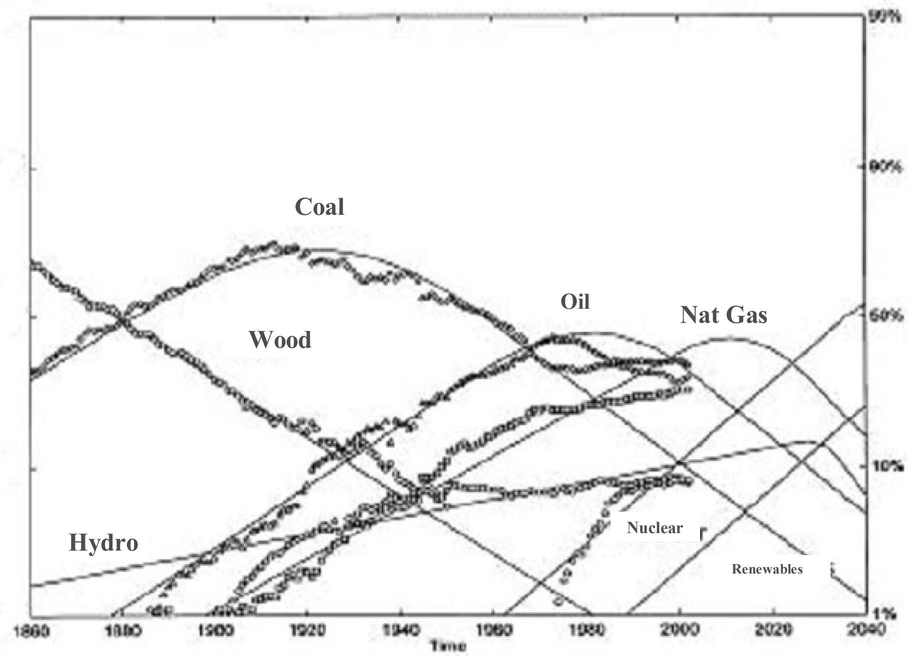


Figure 43 Cycles of Primary Energy Sources and associated energy technologies [NAKICENOVIC 88]

Each primary energy source has been uniquely associated with a set of technologies: for example coal with the steam engine, oil with the internal combustion engine. The technologies that will be required to make the transition to renewables are mostly in their infancy and in some cases uneconomic. By incorporating time extensions, rings and cycles within an integrated design approach, is it possible to envision and possibly manage these slow transitions within urban regions?

In broad terms, it is possible to identify at least three key trends. Firstly, the progression involves an increasing ratio of hydrogen to carbon, which suggests that the next fuel after methane (with only one carbon atom) is either pure hydrogen for some new mixture. Secondly, the quality of the fuel goes from coarse solids to increasingly fine liquids and gases, with a corresponding increase in controllability, which suggests that the next energy delivery system will be much more flexible. Thirdly, the efficiency of energy systems for engine power, lighting, and heating has improved by an order of magnitude with every transition, which suggests that the next energy technology will be factor 10 relative to current natural gas systems. [HOLLINSHEAD 05]

Although such trends may be useful aids in forecasting possible design opportunities, what is more interesting is that each of the sequences appear to undergo a discontinuity sometime in the next 30 years. Moving from carbon-based fuels to a complex mix of renewable and non-carbon fuels is the first discontinuity. Pure hydrogen must be first separated from other molecules, which means it is not a primary energy, but rather is an energy depository or carrier that depends upon raw materials. Both these facts make a difference for urban system design. The raw materials from which hydrogen is derived include sunlight, human and industrial waste, water, plant cellulose and sugars. These exist everywhere cities are located. Thus in a hydrogen-based system, fuel supply becomes more local. It is difficult to monopolize or conquer. The world-straddling transportation systems to deliver energy to cities become less critical. During the next 30 years – the transition period - methane is the likely to be used as a bridging fuel – providing a convenient source of hydrogen. Thus the advantage goes to urban regions closest to natural gas reserves, and cities elsewhere are exposed to the vulnerabilities of a global network of methane pipelines and LNG terminals. Alternatively if the local energy sources are converted directly into electricity (micro hydro, bio-gen, PV, tidal, wind, osmosis) then the advantage goes to urban regions with a temporal balance of supply systems and with intelligent networks that allow for integration of sources, automatic demand response at the end use, and an exchange of surplus power with neighbouring networks.

Moving from molecule-based heat and pressure systems (pyrotechnologies) to subatomic 'cool' systems (electrochemical and microbiological) is the second discontinuity. In rough numbers, the steam traction engine weighs a tonne, the internal combustion engine a hundred kilos, the fuel cell 10 kilos. This is a drop in two orders of magnitude, for approximately the same output. Thus the size of infrastructure systems has continually fallen for a given power output, and this trend is likely to continue for a long time. The trend towards greater efficiency emphasises the benefits of enabling local designers to integrate micro energy systems within the larger networks.

Moving from chunky matter to invisible particles - micro chips, gene splicing and nanotechnology - is the third discontinuity. Electrochemistry involves the reordering of atoms though chemical reactions facilitated by catalysts and electrical currents. Fuel cells, for example, bring together hydrogen and oxygen with a catalyst, such that an electron is stripped from the hydrogen to create an electric current. Microbiology brings together microbes and enzymes together to alter materials at the molecular level for gene splicing. Cool technologies create potential for a synthetic, fine scale of integration for supply and demand systems throughout an urban region.

The exponential improvements in both efficiency and controllability suggest a transformation in energy technology and associated manufacturing processes.

Both processes can become far more decentralised. Hollinshead elaborates on this trend: "The efficiency of fuel cells is based on the amount of reactive surface that can be created in the cell. This depends on the ability to finely divide the material into a porous matrix in a controlled way. Right now the matrix consists of clumps of materials consisting of millions of molecules. The limit of division is not reached until the matrix is divided into single molecules. The power density of proton-exchange membrane fuel cells is doubling every seven years. That pace of improvement will continue for decades as nanotechnology enables ever finer division of materials." [HOLLINSHEAD 05] The implications of such transformations are not obvious for urban design. Advantage may go to those urban regions that work to integrate industrial and municipal ecologies at a fine scale, and that develop the network capacity for sharing information and material flows between nodes and systems at all scales.

It is logical to assume that the combined effect of localization of the energy sources, and the efficiency and miniaturization of energy technology, is that infrastructure systems will become much more efficient, distributed, diverse and dynamic. Since urban form, density and location tend to reflect the energy technologies, if follows that land use systems are likely to become less 'planned' and static, and that the connections between the elements within urban regions will become more dynamic. Large centralized facilities and large transmission and transportation corridors will follow the path of computers, which took 20 years to shrink from room-sized mainframes in universities and defence establishments to laptop computers on everyone's desk. The connecting systems also become more fluid, with many parallel pathways, self-regulating cells, and anonymous service providers. The intelligent networks may serve to manage flows so as to minimize peaks and share surpluses. The facilities can be close to home, and therefore can become architectural elements of the neighbourhood, blended into other buildings. Thus the net effect of the trends in energy technology appears to be a multi-directional, multi-functional system that is the physical manifestation of the network society at an urban scale. [MOFFATT 2000] [GRAHAM 03]

These traditional 19th and 20th century infrastructure systems are becoming increasingly costly to operate on a per person basis. A number of trends contribute to these rising costs, including declining on-site demand for resources per dwelling; decreasing average occupancy per dwelling; increasing costs for securing energy and water resources and for acquiring land for facilities and distribution systems. The cumulative effect of such trends is that a growing proportion of resources is being used in unproductive generation and distribution operations. Thus a combination of economic and technical forces may facilitate a transition in the design paradigm.

In their book on *Urban Infrastructure in Transition*, Guy, Marvin and Moss describe the difficulties faced by existing infrastructure systems as they encounter a new technology paradigm. The dominant logic of network management in Europe for the past century has been 'expand and upgrade'. "Until recently, infrastructure management in Europe has been dominated by a public service ethos to provide adequate and secure services available and affordable to all. The overriding aim has been to build supply capacity and extend the physical networks. …. Under this supply-driven logic there has been very little interest in shaping the intensity, time or place where demand is routed." A territorial monopoly has enabled long-term investments with little social or spatial differentiation, and with a predominately one-way and top-down. Resource management has been focused principally on reducing emissions. In technical terms the utilities have been unresponsive to local specifics, and "fail to influence planning processes early enough to affect the outcome." [GUY 2001]

As the paradigm changes to a distributed network, the urban system also reduces the resource demands associated with the delivery infrastructure and transmission– variously estimated at 10 to 15% of the total. With more looping and processing of resources 'on-site', the potential is created for immediate re-use or cascading of resource flows with corresponding increases in efficiency. A similar process used on the factory floor (Pinch Analysis) has generated substantial process efficiency gains, variously estimate from 10 to 30% for energy flows, and possibly higher for water and materials. Is the potential for savings at the regional scale similar? At present, experience with industrial and municipal ecology is very limited and the potential for system-wide efficiencies is unknown. However it is reasonable to assume that by matching the quality and timing of flows it becomes possible to minimize entropy for each end use. With the right incentives and information flow, the entire urban region can slowly move towards an ecological model for energy management.

While such potentialities provide one useful scenario for long-term urban system design, the complexities of the forces involved undermine any certainty over what might occur over the next 30 years. For example, miniaturized and localized systems, combined with innovations in work due to ICT, open a wide door to exurban sprawl. Cities may disintegrate, especially if they are unable to secure local raw resources for on-site energy, water, food and manufacturing. If clusters of residences and workplaces become untethered from the industrial-age grids, a scenario emerges where a new generation of pioneers colonize remote and pristine locations virtually anywhere on the planet. Thus impact of external forces is likely to be great, but it is still important to plan for multiple futures and to prepare for surprises. This is the subject of the next chapter.

5.3 The Essentials

Significant synergies exist between urban systems if where extended design horizons permit greater integration of slow-moving elements. However actual success in such design approaches may depend very much upon political will, institutional reform, changes in cultural values, changes in mandates for regional bodies and the greater use of an improved set of tools for estimating benefits and costs.

The principles of ecological design provide a rich pallet of principles and examples for urban systems design, based on natural precedents. The application of ecological design principles may ultimately create urban ecologies – cellular structures where all infrastructure blends into an undifferentiated single system that is distributed, interconnected, integrated, adaptable, low-impact, service oriented, self-organising and multi-purpose. Ecological design may also provide guidance on how urban systems can evolve over time – through succession and evolution – to improve their net efficiency and adaptability.

Historical views of urban areas suggest that many cycles and patterns exist that hep to define how urban systems may evolve over time. Energy and technology systems in particular show recurring cycles that are possibly the most significant factor affect urban form, size, density, location and prosperity. When urban systems are analysed within such context, it is likely that the next few decades will witness a radical change in the urban regional design. Large mono-centric urban regions may disintegrate into widely dispersed self-reliant clusters on open networks, with more looping and cascading at the local scale.

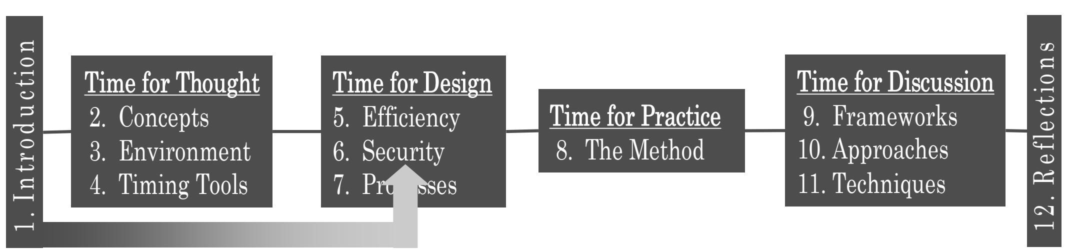
Ecological design appears to offer a positive, long-term perspective on how to resolve environmental constraints through more efficient and adaptable design at the system level. It may also provide a scientific basis for how to incorporate temporal factors more thoroughly into architecture and urban design.

6 How Might New Time Concepts affect System Security?

Since early human history security is a concept that has defined civilization. Living in towns and cities required that people exchange a measure of freedom for a measure of protection. Cities could accumulate the supplies needed to survive hard times, and provide the institutional structures for law and order. With the evolution of cities into modern nation states and the integration of cities into a global economy, the concept of security has continues to evolve.

At the moment the discussion on sustainable urban design tends to focus on how to harmonize rates of consumption with constraints imposed by natural systems. For example the high profile ICLEI[15] programs, The Zero Energy Development[16] projects, and the Natural Step Communities[17] all focus on reducing ecological footprints to levels that reflect a fair allocation of estimated global resources. The implicit assumption is that the designs must achieve a steady-state. This mind-set tends to obscure the inevitable cycling of both natural and built environments over time. It also ignores the many and diverse threats that can undermine the performance of urban systems over time.

Perhaps a more reasonable assumption for sustainable system design is that some degree of security, in the face of changing circumstances, is a prerequisite for sustainability? If so, all key design choices may need to be assessed in terms of their affect on threats and vulnerabilities. Is it possible to design systems that are inherently more capable of withstanding surprise and shocks, and more capable of rapid and full recovery from rapid change or disasters? How can designers acquire familiarity with threats and hazards, and with tools for evaluating and managing risk? This chapter will explore how time concepts affect the security of urban systems.



[15] ICLEI:
www.cities21.com/index.php?id=1504&tx_ttnews%5Btt_news%5D=498&tx_ttnews%5BbackPid%5D=983&cHash=2afaea8d5e
[16] See BedZED http://www.zedfactory.com/bedzed/bedzed.html
[17] See The Natural Step Communities http://www.naturalstep.org/com/nyStart/

6.1 How do Extended Time Scales influence Security in Urban Design?

6.1.1 The emerging concept of urban security

National Security

Centuries ago security in urban design meant strong city walls, deep wells and ample grain storage. However throughout most of the 20th century the term became synonymous with national security. Governments of the world's leading powers defined and thought of their interests in terms of "threats to national interests" which included external aggression, internal political conflict, transnational crime, and international terrorism. Security was about protecting the nation state, which subsumed the interests of cities and citizens. [FARSON 03] For the major powers in the first half of the century, security was achieved by maintaining a 'balance of power'. During the Cold War, in a bi-polar world, security was achieved through 'Mutually Assured Destruction'. With the emergence of a single super-power in 1989, security meant alliances or negotiations with the USA, and participation in economic partnerships, trade agreements, broad defensive pacts and multi-national peace-keeping.

At the end of the Cold War it was largely expected that the influence of a hyper-power, and the emergence of a truly global economy, would increase both security and welfare for people world wide. But the evidence now suggests otherwise. [SAUL 06] Not only has the number of desperately poor people continued to rise, but the world has witnessed a series of horrendous regional and internal conflicts that claimed the lives of millions of people in regions like Africa, Asia and Eastern Europe. At the same time the expanding reach of international media – the 'CNN factor' – has created a window on the world in every living room. By the early 1990s the entire developed world was confronted with the spectre of genocide, ethnic cleansing, failed and lawless states, and massive refugee flows. The media magnified the power of non-state actors by fostering a collective intelligence and by facilitating collective action. [MCRAE 01] A global conscience began to coalesce and demand a search for a coordinated international response. [DORN 2001] Was it possible for the civilised nations to find effective means and mechanisms to protect human beings everywhere, especially the many innocent victims of armed attacks?

Human Security

In 1994 a UN Human Development Report began an exploration of the "new concept of human security", defined by the authors as "safety from chronic threats and protection from sudden hurtful disruptions in the patterns of daily life." [UNDP 94] This people-centred concept was based on the same premise as the related concepts of human rights and human development, namely, that the individual human being is the principle object of concern, regardless of race, religion, creed, colour, ideology or nationality. “Like its sister concepts, human security has the characteristic of universality: it is applicable to individuals everywhere.” [DORN 01] In many ways the concept of human security is inextricably linked to other human development rights, like access to food and basic services. “Freedom from fear and freedom from want … are complementary and mutually reinforcing. Without one, the other becomes difficult, if not impossible.” [Dorn 01]

The scope of human security includes not only personal (or physical) security, but also economics; food; health; environment, community and politics. Thus the range of actors providing security expands beyond military and police forces to include the development community and civil society, especially non-governmental organizations providing humanitarian aid, disarmament and re-construction.

The notion of human security was not especially well received in the UN, where it appeared to justify UN interventionism and to undermine the sanctity of national boundaries. However Canadian Foreign Minister Lloyd Axworthy, who later served as the national chair for Greater Vancouver’s long-term urban system design, made human security his hallmark, and brought Canada to a leadership position on the issue. With Norway, Canada founded the international Human Security Network, a group of nations that continues to promote the concept. The Canadian foreign ministry developed a "Human Security Agenda" which has come to define much of Canada’s foreign policy - from the convention on landmines to the rapid deployment of peacekeepers. In 1999, Axworthy summarized Canada's human security policy thus: “ *It is, in essence, an effort to construct a global Society where the safety of the individual is at the centre of international priorities and a motivating force for international action; where international human standards and the rule of law are advanced and woven into a coherent web protecting the individual; where those who violate these standards are held fully accountable; and where our global, regional and bilateral institutions - present and future - are built and equipped to enhance and enforce these standards*.” [quoted in MCRAE 01]

Domestic Security

Another characteristic of the post Cold War period has been the emergence of increased domestic security as a response to so-called asymmetrical warfare, in which relatively small entities such as terrorist groups attack nation states. The September 11th tragedy in New York was a reminder for the world at large of the security risks to cities resulting from ‘Operations

Other Than War' (OOTW), - a term now in common use by the military and intelligence community. According to a recent review by the Institute for Alternative Futures, "the major adversary between now and 2020 will probably be chaos, not another coherent military force", and may be as important for the 21st century national security as deterrence was for the Cold War." [OLSEN 99]

The most prominent and extreme response to OOTW is the new *Department of Homeland Security* in the US. According to Farson, this represents a massive reorganization of government on a scale not seen in decades. In theory the new Department can set the direction for all Federal agency involvement in preventing attack, reducing vulnerabilities, minimizing damage and speeding recovery. [FARSON 03] [WHITEHOUSE 02] In theory the Homeland Security plan provides accountability and leadership for all initiatives, and the scope includes security for critical infrastructure and assets. However the plan, along with similar initiatives in Canada and elsewhere, is essentially a national security strategy for the domestic scene, focused almost exclusively on threats from terrorist sources.

The homeland security example illustrates the importance of individual perception and belief in security concepts. Security is in large part about how people feel about the environment in which they live. For example, many Canadians believe that crime is increasing when in fact incidence research shows it is declining. Both personal experience and media coverage can colour perceptions. Catastrophic events, such as those that occurred in New York on September 11th, 2001 can lead to perceptions of tremendous vulnerability, which in turn leads to anxiety and significant reactions. Similarly, everyday practices that are largely hidden from public view, like organized crime and climate change, have potential for very negative consequences but receive relatively little attention.

Urban Security

In a rapidly urbanizing world the security of both the human being and the nation state is increasingly linked to the middle ground – the urban systems upon which depend the society and its economy.

Except for the anomaly of city states, the concept of urban security is only beginning to emerge in public dialogue. In Canada, the government sponsored its first workshop and conference on urban security in 2006 and launched a new policy initiative on human security in cities. The government is questioning "What is it about an urban environment that assures human security or makes its achievement more difficult, and how does it interface with human and state conflict?" [18] A federal discussion

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[18] http://humansecurity-cities.org, accessed June 06.

paper, *Freedom for Fear in Urban Spaces,* has recognised the centrality of urban spaces for achieving security in the modern world [see DFAIT 06]. Although the urban focus may be an important step forward, the focus is still exclusively on socio-economic problems such as violence from gangs.

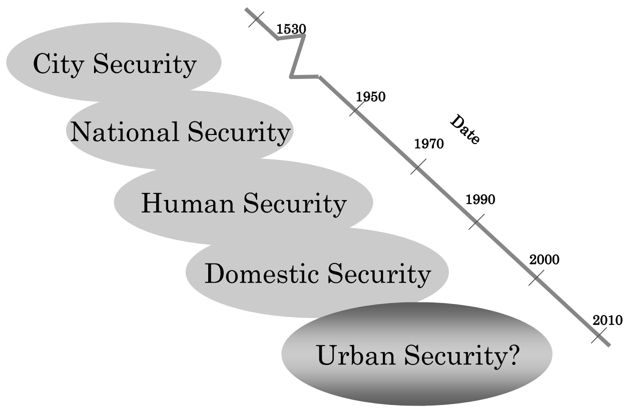

Figure 44 The progression in concepts of security reflects a more complex world, and also a return to the urban scale that characterised 16th century security

In fall 2005, ICLEI launched its *Climate Safe Cities* program to help local governments throughout the US improve their resiliency in the face of increasing climate disruptions and catastrophes that stem from global warming. The program proposes to use tools and develop strategies that reduce hazards and manage risks related to regulations, planning, urban design, and investments. [ICLEI 05] Such efforts may help to forge a new security paradigm that accommodates the increasingly specific nature of threats and vulnerabilities faced by urban regions.

6.1.2 Global Inter-dependencies

Part of the challenge in re-defining security is the level of inter-dependency between cities and between systems. Infrastructure systems for regions like Greater Vancouver are no longer confined to polygons on a road map. A 'Class II' world city, Vancouver functions as a node on a vast global network upon which it depends for many critical supplies including energy, food, information, consumer products, and employment. Even the city's population is derived from global connections, with over half the residents born outside the country. It is hard to imagine a 'sustainable urban region' for Greater Vancouver, unless the principles of sustainability also apply to the communities at the end of these import-export chains. The chains create interdependencies and vulnerabilities that are not addressed by conventional security providers, and which can vary greatly from one urban region to another. [OCIPEP 05]

Vancouver, as a gateway city, is especially vulnerable to loss of a major trading partner. Closing the border with the USA, for example, could cripple the city within two weeks.[19] A collapse of a major city in the developing world might also impose massive difficulties for a multicultural city like Vancouver, as it tries to cope with providing humanitarian aid and accommodating a mass migration of refugees with blood ties to the region. Regularly sending money and resources abroad, imposing quarantines, or accepting many thousands of immigrants are consequences that may compromise the region's long-term urban sustainability. Many more such examples can be imagined, and suggest the need for foresight, contingency planning, a diversity of global partnerships, and an expanded scope for emergency planning and reserve funds.

A similar level of complexity and dependency is emerging in the environmental sphere, as a result of growing ecological footprints for modern cities. [REES 01] Greater Vancouver's ecological footprint is 15 to 20 times the area of the city itself. [WACKERNAGEL 96] Much of the productive ecological area upon which the city depends for such things as food, building materials, clear air, energy, and climate control lie outside the region. How secure is a region if this remote and essential ecological infrastructure is at risk? And how can such risks be managed over the long-term, as ecological systems deteriorate world-wide?

To some extent the long-term sustainability of a region like Greater Vancouver is inextricably linked to the ability of larger cities in developing countries to withstand natural and economic disasters, and to improve resiliency. If so, Greater Vancouver's greatest challenge may be assisting cities in the developing world, where crowding, poverty, corruption or mismanagement compromises infrastructure systems. In his book *At Risk, natural hazards, people's vulnerability, and disasters* Ben Wisner (et al) describes the very different results of similar hazards on rich and poor cities. [WISNER 04] From this perspective a disaster is more a function of the vulnerability than the hazard.

Kenneth Hewitt, writing on *Regions of Risk, a Geographical Introduction to Disasters*, also emphasises the very large differences between regions in their means and ability to respond, and the protection afforded by system design. He argues that "the geography of risk or disaster depends most critically upon differential vulnerability within and between societies. He also argues that vulnerabilities can be dramatically altered by social change, and that "vulnerability is surely decisive for the growing concern over 'sustainable' human communities and environment relations."

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[19] A conclusion based upon personal discussions with transportation planners on the *CitiesPLUS* Transportation Foundation Team, 2002.

[HEWITT 97] Despite Hewitt's focus on regions and a vulnerability approach, and his recognition that cities play a vital role in determining vulnerability in modern times, he neglects to examine any urban design issues and devotes only a few paragraphs to safe cities. Perhaps a sustainable approach to risk management requires that geographers and social scientists work much more closely with the design community and develop indicators for evaluating urban resiliency.

Even with more attention given to urban vulnerability and system design, it is prudent to assume that such efforts will be largely ineffectual given the current pace of urban growth. Vulnerabilities will increase in parallel with urbanization, and the future will be punctuated by a variety of city-based disasters and societal collapse. Research institutes worldwide have identified this threat repeatedly. [RASKIN 02] [HAMMOND 98] In fact most global forecasts for the next 10 to 20 years include scenarios where regional economic or environmental systems collapse – for one reason or another. Under such conditions the more technically advanced regions are likely to defend their wealth and standard of living, creating a 'fortress' world with pockets of wealth and privilege possibly surrounded by chaos and deprivation. In the long-term it is difficult to ignore such a scenario; in a fast changing world with over a million towns and cities, perhaps many such scenarios are plausible, and may play out at different times and places. Thus urban system designs need to presume the collapse of one or more global systems of trade, and incorporate early warning systems, contingency planning, redundant facilities and a degree of self-reliance for critical needs like food and water.

The global trends towards concentration of ownership into 'families' of transnational companies may frustrate efforts to create local security. By way of example, during the course of this research Greater Vancouver's natural gas wholesaler (Westcoast Energy) and its natural gas retail distribution utility (BC Gas) were both purchased by American companies located in Chicago and Houston respectively. As a consequence, much of the research, long-term planning and strategic decision-making functions for Vancouver's critical energy infrastructure system are now removed to remote locations.

The dynamic between localisation and globalisation forces is nothing new. However it can be argued that today's conflicts are more fundamental than any previous time, and may become a defining characteristic of the century ahead. In their discussion paper on *The Secure City* Axworthy et al argue that urbanization and globalization combine "to create a network of inter-dependant mega cities that represents a phenomenal challenge to the effectiveness of contemporary models for planning, design and governance…..the impact of environmental disasters ranging from large scale, naturally occurring events such as earthquakes and mudslides, to more localised catastrophes … demonstrates how inter-dependent, interactive and fragile our systems and networks have become. Threats such as these expose the intrinsic vulnerabilities of city form and function." [AXWORTHY 06]

Recent protests against WTO policies and third world debt loads are driven by a belief shared by many that regional economies and community health can be deformed, or even destroyed, by a global trading system that serves special interests or national interests at the expense of community. Even if agendas are not in conflict, is it possible to avoid shocks in a world where local economies are so closely interconnected with a continental or global trading system? Over the past decade all cities have witnessed how events far away can rapidly alter the local price and availability of water, electricity, gasoline, natural gas, steel, copper, lumber and agricultural commodities. Such shocks can undermine key policies for achieving sustainability. For example in Greater Vancouver a sudden 27% increase in natural gas prices in January, 2001 was stimulated by events elsewhere (an expanding continental market and a cold winter in the US). The price hike created significant stress for the region's greenhouse and horticultural industry, as they were dependant on substantial natural gas inputs. As the industry tried to survive by switching to cheaper (and dirtier) fuels, the region had to re-evaluate air quality objectives for sustainability in the Fraser Valley.

6.1.3 Risk Management

The potential broad scope of security concerns within cities represents part of the challenge in managing risk. Even the elements of 'critical infrastructure' are difficult to define in an increasingly complex economy. [MOTEFF 06] The potential scope is illustrated in Figure 45. With the recent privatization of many airports, ports, and railways it is now estimated that 80% of this critical infrastructure is privately owned. Who is responsible for securing this 'critical infrastructure' and ensuring that vital activities, services and functions can be practically replaced or repaired within a narrow time frame?

Elements of critical infrastructure:

The energy producing, storage and distribution systems (high tension lines, hydro dams, natural gas producing plants, oil and gas storage etc), the financial sector (banking systems, social welfare), health and emergency services (ambulance and other rescue services, civil defence, fire departments, and hospitals), food distribution and storage systems, aspects of governance (border controls (coast guard, customs, and immigration), certain government institutions (federal, provincial and municipal, military and police), telecommunication systems (internet, radio, telephone, and television), transportation networks (airports and airlines, bridges, inter-island ferries, navigation traffic control systems (air, sea lane and road), road and rail links, and utility systems (waste management and water supply).

Figure 45 Critical infrastructure can include a long and diverse list of elements, which makes it difficult to evaluate vulnerabilities and define the scope of mitigation measures

As systems privatize and diversify into the complex ‘urban ecology’ described earlier in Chapter 7, the number of key players will only expand. It may no longer be sufficient to inform a small cadre of ‘security-cleared’ people about impending risks. The national security services may need to localise and to share information much more widely. Some small efforts towards this end are occurring. In Canada, after the events of 9/11 an *Infrastructure Security Integrated Intelligence Scheme* (ISIIS) was established with a view to sharing information produced by the Government of Canada with regions like Greater Vancouver, and with the private sector. Although still in its infancy, discussions with regional planners suggests that the information is not always timely or relevant. [FARSON 30]

One of the challenges to defining urban security is the scope and variability of the threats and vulnerabilities. Traditionally the nation’s intelligence and police services have addressed crime and national security matters, while the nation's public safety administration address health issues. The local emergency planners are focused primarily on natural disasters – for example earthquakes are the biggest issue for Greater Vancouver's emergency planners.

Over the past decade, local emergency planners have recognised the increasing scope of potential disasters, and have adopted an 'all-hazards' approach. Despite the label, there would appear to be no actual examples of an 'all-hazards' approach. These local groups tend to ignore many social, economic and ecological hazards, as well as certain types of crime and endemic health threats. Moreover the complexity of urban regions, and the rapid pace of change for many key forces affecting urban areas, may make it impossible to even define all-hazards. While a typology of hazards can be constructed (e.g. man-made, natural,) the actual list of possibilities seems to expand as a function of the number of institutions interviewed. And every year still new threats emerge.

At the urban scale, governance systems for urban security typically include the emergency planning and response organisations, and their systems for educating public and preparing for disaster response and recovery. Facilities include the emergency command centers, hospitals, emergency shelters and gathering locations, back-up supplies and reserve facilities. The emergency planners typically include police, fire, ambulance and major utilities (energy, water). In Greater Vancouver, for example, the Joint Emergency Liaison Committee (JELC) is a body that brings together all the municipalities in the region, the province and the utilities. A JELC sub-committee of municipal emergency planners establishes systems for sharing of information and resources and for the coordination of response plans. [JELC 05]

The most common approach to security risk management is a vulnerability analysis (also referred to as a Threat and Risk Assessment or TRA). A vulnerability analysis prioritises security resources by means of a four-step process: identify assets, identify threats, assess risks and recommend security measures. [RCMP] Recently a number of jurisdictions are attempting to assist cities and towns with vulnerability analysis. For example, as part of its '*Disaster Resilient Community*' initiative, the B.C. Provincial Emergency Program has developed a comprehensive *Hazard, Risk and Vulnerability Analysis* (HRVA) Tool Kit. This is available on its web site along with a community self-assessment tool that identifies more than 50 different types of hazards. [PEP BC 04]

The HRVA Tool Kit was developed by a committee of experienced emergency planning professionals, and is a good illustration of their current narrow mind-set. Despite the use of the term 'disaster-resilient' the concept of resiliency is no where defined or discussed. The proposed analytical procedure is an untried process, with no case study examples. The focus is almost exclusively on natural disasters. The planning process is assumed to be a time-limited, once-through exercise. The scope of remedial actions is limited to short-term response and recovery strategies. The composition of the planning team is assumed to be limited to police, fire, ambulance and other 'early responders'. And finally, the town or city is analysed in isolation from the surrounding rural or metropolitan areas.

6.1.4 Long-term Threats and Vulnerabilities

Extended time horizons may help emergency planners and designers to address more cyclical patterns of performance, and to define a scope of potential threats and vulnerabilities more suited to the long lifetime of many infrastructure investments.

Estimating the likelihood of natural disasters

A disaster occurs when damage is so extensive that impacted communities need outside help, or when total costs exceed a threshold, for example 1 Billion dollars. Using this general definition, disasters can come in many forms. Wisner et al compare deaths during disasters by cause. Political violence rates the highest (62%) followed by slow and rapid natural disasters (18%) and epidemics (12%). Droughts, and the associated famine and economic hardship, are an order of magnitude greater loss than all other natural hazards combined. [WISNER 04]

Wisner rejects the more common approach of associating disasters primarily with their initial trigger. He argues that almost all disasters are a complex mix of natural hazards and human action. As an alternative he has emphasised the concept of vulnerability, which he defines as "the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard." [WISNER 04] He has proposed the "Pressure and Release model" as a way to emphasise that a disaster is an intersection of two opposing forces: those generating vulnerability on one side, and the natural hazard event or process on the other (Figure 46). To release the pressure, vulnerability has to be reduced, which means the focus is placed upon the underlying root causes, however remote these may appear at first.

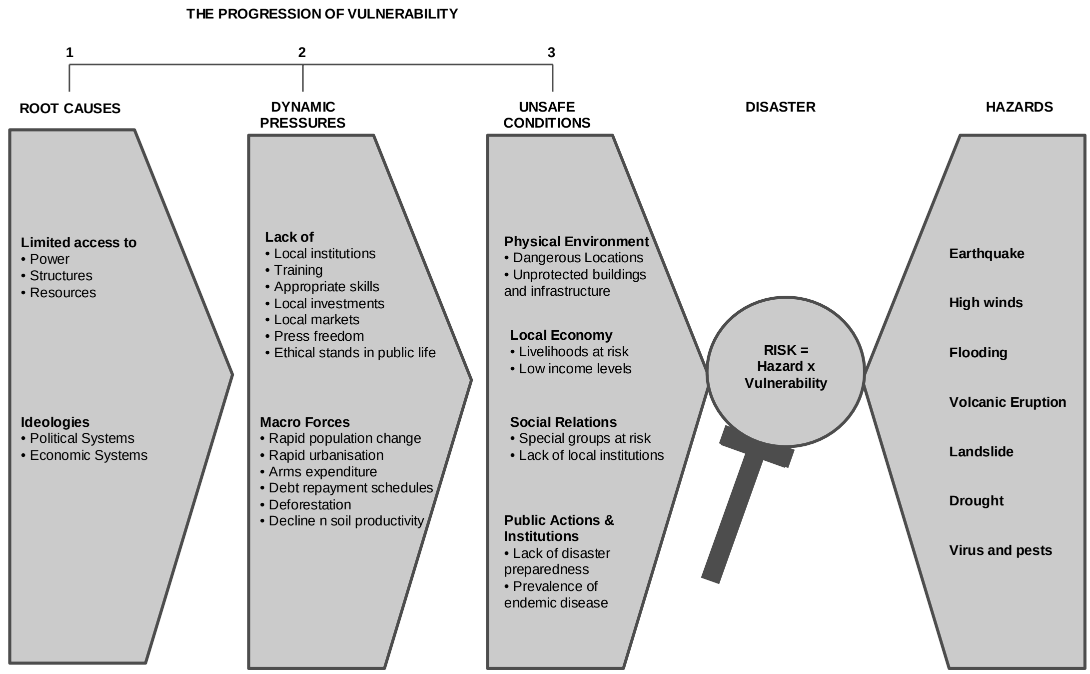
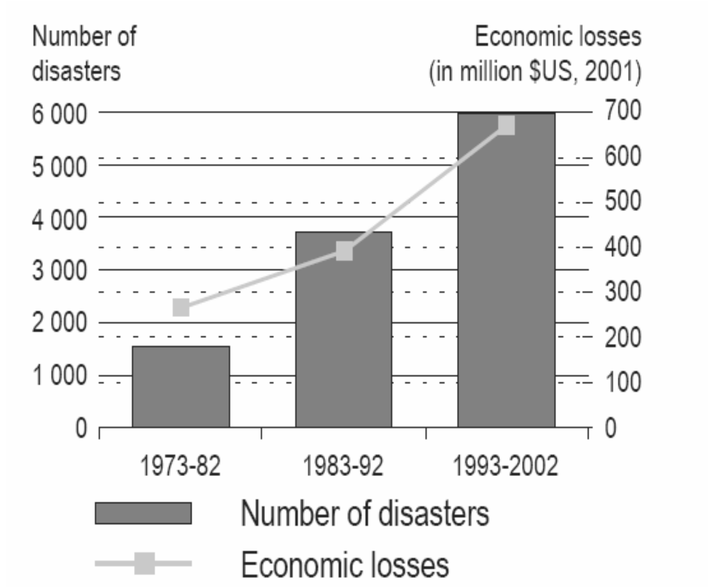


Figure 46 A 'Pressure and Release Model' helps to highlight how vulnerabilities progress from root causes, rather than the more common focus on hazards [WISNER 04, redrawn by author]

The frequency and impact of natural disasters is growing every decade, within Canada and worldwide. Canada has suffered its three most expensive natural disasters all within the last 7 years. Prior to 1990, annual insurance claims for natural disasters never exceeded $5 billion worldwide. During the 90's, claims exceeded $5 billion every year, except 1997[20]. Figure 47 charts the very rapid increase in both the frequency of disasters and the associated costs over the past thirty years. Disasters have more than tripled since the 1970s. Somewhat ironically, the UN had designated the 90's as the International Decade for Natural Disaster Reduction (IDNDR). Only in the final three years did the UN focus turn towards cities. According to Wisner this reflected a judgement by program staff that rapid progress was possible in cities, and also a preoccupation by UN experts on earthquakes. [WISNER 04]

[20] Insurance claims are an indicator of costs of disasters, rather than a valuation. The UN Report on Global Disasters points out that in countries like Venezuela, only 4% of property is insured and thus claims represent only a small fraction of real costs.



Increasing Incidence of Natural Disasters*

* Drought, earthquake, epidemic, extreme temperature, famine, flood, industrial accident, insect infestation, debris slide, transportation spills, volcano, wave surge, wildfire, and windstorm.

Source: EM-DAT: The OFDA/CRED International Disaster Database
www.em-dat.net – Universite Catholique de Louvain – Brussels, Belgium 2004

Figure 47 The incidence of natural disasters has been rising steeply despite the increased focus brought by the UN International Decade for Disaster Reduction [EM-DAT OFDA/CRED International Disaster Database www.dm-dat.net 2004]

Natural disasters are situated at the dynamic interface between the constantly evolving natural landscape and human activity. [SMOG 05] The trend towards increasing natural disasters is a reflection of the proliferation of hazards and the increased vulnerability of communities. Urbanization is a big part of the problem. By concentrating people into a few, dense locations we limit our ability to avoid or respond to natural disasters. Moreover we have located cities like Greater Vancouver in places like the Fraser River valley, where flood plains, debris fans, exposed foreshore, seismic fault lines and unstable soils make populations inherently more vulnerable to natural disasters.

A proliferation of hazards is also occurring. In addition to natural disasters are the many human-induced calamities that can have similar or greater impact. In his book *Unnatural Disasters –Case Studies of Human Induced Environmental Catastrophes* Gunn describes coal mining tragedies, dam failures, government actions, industrial explosions, nuclear accidents, oil spills, and toxicity in residential and industrial areas. He calls these the 'dark side' of technology, and concludes: "More and more, we find that human activity is affecting our natural environment to such an extent that we often have to reassess the cause of so-called natural disasters. … The secondary effects of human action or inaction are an increasingly important consideration the study of disasters." [GUNN 03]"

Since Neolithic times natural disasters have been linked to unsustainable use of land and resources. [DIAMOND 05] In modern times the dark side of technology combines with globalisation and urbanization to create a greater diversity and frequency of hazards. For example, continuous air traffic between cities makes it easier for micro-organisms to move into our large urban populations. Ground water depletion is threatening farms and cities in all continents – the WorldWatch Institute estimates up to 3 billion people in India, the US and China may be facing inadequate water supplies by 2050. [WORLDWATCH 99] Air pollution is becoming global - dust storms in Mongolia have contributed to urban air quality problems in cities on the west coast of North America, from Los Angeles to the Yukon. [*CitiesPLUS* Proceedings 02] Holes in the ozone layer have increased the hazard of skin cancer and the UV damage for cities even in Southern Australia and Antarctica. The list of such disaster scenarios is growing both in depth and scope.

The potential for negative synergy among such unnatural disasters can further multiply the risk. Managua, Nicaragua is an example of an urban region beset by 'domino disasters': droughts and deforestation exacerbated the flooding after Hurricane Mitch, which in turn spread toxic pollutants (from oil refining) and later disease. Climate change may trigger similar domino affects, especially for coastal cities.

It is easy to ignore such disaster scenarios when urban systems are designed for short-term benefit/cost, or when design strategies are based upon a 'frozen' future with no scenario planning. Long-term horizons, on the other hand, cannot easily avoid scenarios where disasters are a distinct likelihood. In Greater Vancouver, for example, the likelihood of a major earthquake over the next 100 years is greater than 60%. When a design team began their regional long-term design, the first step was to assume that at least the land base was something that could be assumed to remain unchanged over the century ahead. But the security experts who were present quickly corrected this assumption. They recalled that in 1700, when the last large quake (8+) hit the area, an estimated subsidence of 10 meters caused significant portions of the shoreline to disappear and destroyed some native villages. [NRCAN]

Dennis Mileti, writing in *Disasters by Design*, warns that many mitigation activities are not preventing damage but merely postponing it, with potential enormous losses. By building dykes and allowing people to build on flood plains, or by constructing all buildings to a threshold level of earthquake resistance, we fail to admit the inevitability of failure. When the dam finally bursts, or the big quake arrives, everything is lost. [MILETI 99] Jared Diamond, at the end of his book on *Collapse, How Societies Choose to Fail or Succeed*, reviews the history of the Pacific Ocean island societies, the Anasazi, the Maya, the Vikings in Greenland and locations in history where natural hazards have ultimately destroyed civilization. At the end in concludes: "Two types of choices seem to me to have been crucial in tipping their outcomes towards success for failure: long-term planning, and willingness to reconsider core values. … One of those choices has depended upon the courage to practice long-term thinking, and to make bold, courageous, anticipatory decision at a time when problems have become perceptible but before they have reached crisis proportions." [DIAMOND 06]

Risk and Uncertainty

Most researchers working in the field of risk and natural disaster focus on the less developed countries, where poverty combines with unstable institutions and sub-standard technology to exacerbate vulnerabilities. An exception to the rule is the work of Ulrich Beck and the school of ecological politics which emphasises the types of risks that are increasingly prevalent in the more developed countries, despite their wealth, institutional capacity and technology. Beck, writing in *Risk Society* argues that the world is in a transitional state between industrial society and the risk society. "The gain in power from techno-economic progress is increasingly overshadowed by the production of risks." [BECK 92] The new risks to which he refers are the dark shadows of modernity: cancer, toxic wastes, radiation, industry-induced disease, terrorism, smog, global warming and so on. They escape perception, affect rich and poor, and tend to be global. The risks are the implicit and global counterpart of industrialisation; - the consequences of continuous wealth accumulation and the technological system. Beck claims that these risks were once small in relationship to the benefits of global industrialization, but they are now becoming a defining element of the consciousness in our age – at least in the developed world. With the term 'reflexive modernity' he describes an institutional activity and state of mind involving constant monitoring and reflection upon a diversity of risks ranging from threats to the individual to global risks like climate change and loss of biodiversity.

From Beck's perspective the design of resilient urban systems may help to reduce the risk of environmental crises for cities, but it is only a partially solution to urban security. Global risks of different kinds emerge every year, and technological solutions may exacerbate the problem if the root causes of risk are global capitalism and its need for hyper-consumptive lifestyles. A truly effective urban response would presumably require a radical change in the types of technology and economic relations that are an integral element of modern globalisation. Until that occurs, shadow risks will follow us, and perceptions of risk may absorb us.

The changing nature of risk perception is reflected in the precautionary principle – a design rule that reinforces Beck's analysis. Rather than seek solutions from scientists and technology, the precautionary principle recognises the very real likelihood of unknown and unintended consequences. The principle speaks to the importance of separating risk management from methods for coping with uncertainty. Frank Knight, in 1921 differentiated risk and uncertainty: "Risk becomes uncertainty when factors are poorly described by quantifiable probabilities." [LEMPERT 03] The RAND team argue that long-term policy formulation must cope with deep uncertainty – a condition where the analysts do not know – or cannot agree upon – the appropriate models, the sensitivity of the models to key parameters, and the value of alternative outcomes.

Smith emphasises how both uncertainty and expectation are central themes in all social science. [SMITH 89] Uncertainty is unavoidable due to the haziness of expectations and the inevitable changes that occur with other aspects of the world as a consequence of the passage of time. Smith argues that a key role for social institutions is to reduce uncertainty in human events – to make the future more knowable. It is for this reason that constitutional arrangements, economic systems, political arrangements, and the constructed environment should avoid excessively high rates of change. What Smith does not address is how to cope with heightened uncertainty that is itself a direct outcome of the institutional arrangements we have created.

Vulnerability to powerful external forces

Similar to natural disasters, many of the driving forces that will transform urban regions over the century ahead are largely external to the sphere of influence of local decision-makers. Economic, social and environmental threats can seen as the 'dark-side' or shadow threats behind any vision of sustainability, as shown in Figure 48. Foresight, and alliances with other regions, may serve to mitigate such threats to some degree. However in light of the pace of change, the best defence may be to design urban systems with shadow threats always in mind.

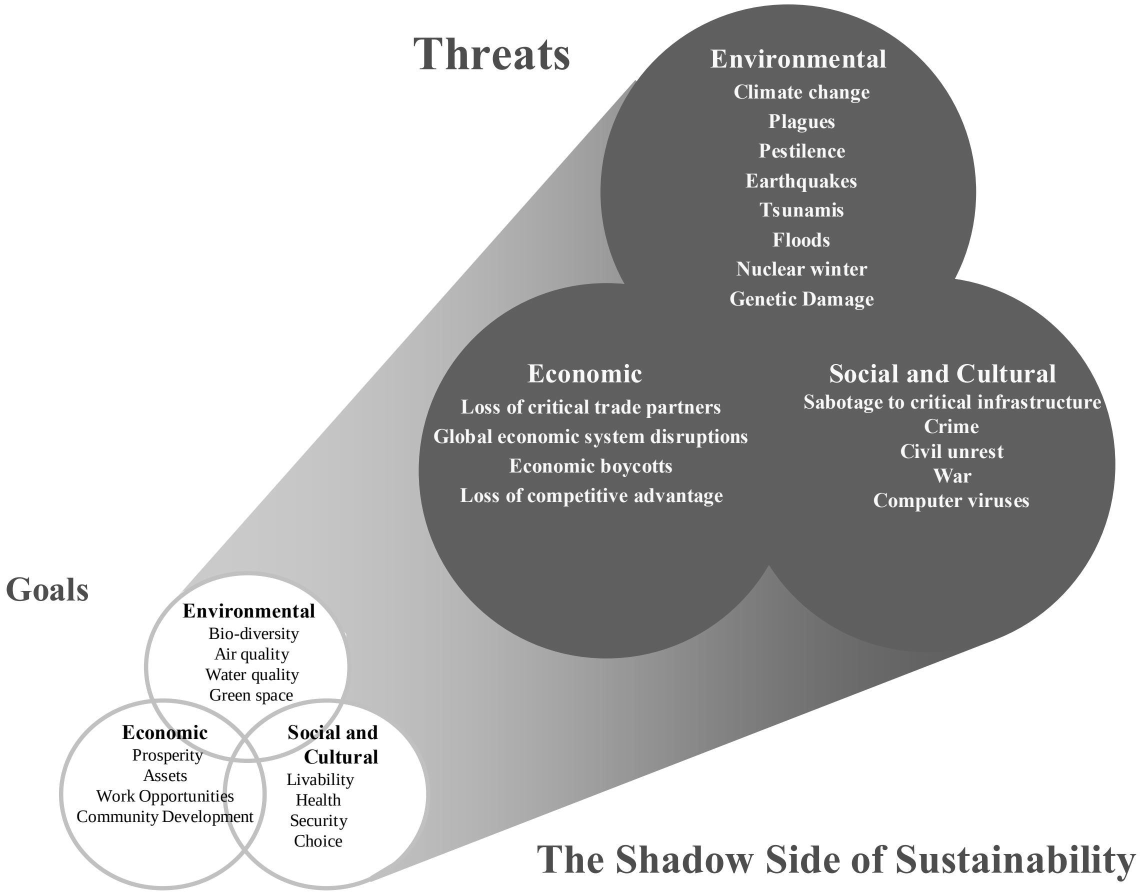


Figure 48 The spheres of sustainability are shadowed by a continuously growing and changing set of threats

The shadow threats may impact any part of a city's critical infrastructure, and suggest that a change in mind-set is needed for infrastructure designers. A major problem with today's centralised, top-down systems is their inherent fragility when faced with rapid changes in external conditions or local priorities. If the centre falls, failures can cascade throughout the system. The loss of a single power line, pipeline or bridge can now shut down an entire city, as we have seen in the ice storms in Quebec and Ontario, Canada. The situation has not changed significantly from when Lovins described the risks to America's energy systems, 24 years ago, in his book on *Brittle Power.*

Lovins divides threats into four categories: natural events; aggressive physical acts; failures of complex technical and economic systems; and accidental failure or deliberate disruption of the control devices. Lovins concludes that vulnerability to such threats is an unintended consequence of the "nature and organization of highly centralised technologies." He cites many structural and design attributes – the 'seeds of brittleness' - that contribute to vulnerability of the energy infrastructure, including: use of dangerous materials, centralization of supplies, long haul distance, limited substitutability; continuity and synchronism in large grids, and inflexibility of delivery systems. [LOVINS 82] Although Lovins focuses only on power systems, it is clear that many of these brittle design attributes apply to other types of urban infrastructure.

Unfortunately the inherent dependencies and inflexibilities of the 19th century models for urban systems are proliferating into the 21st century, as much of the developing world emulates the infrastructure models used by cities like Greater Vancouver. Even within the developed world the level of innovation within infrastructure systems is moving slowly. Some of the most notable case study work in Europe has been discussed and documented by the *European Committee on Scientific and Technical Cooperation, Action C8* which has produced conceptual guidelines and a series of diverse case studies on Energy, Water, Sewerage, Waste, and Assessment systems.[21]

In Canada investment in more sustainable infrastructure design is being encouraged by *InfraGuide*[22], a national collaborative of government agencies, research institutes and municipal associations dedicated to develop and disseminate best practices and tools that encourage innovation. *InfraGuide* has produced multiple guides with very basic information in each of seven subject areas: Water, Decision-making, Storm and Wastewater, Roads and Sidewalks, Environmental Protocols, Transit and Multi-disciplinary approaches.

In the USA the most notable example of innovative design is the recently released *High Performance Infrastructure Guidelines* for the City of New York.[23] These include detailed design practices and illustrations for Site Assessment, Pavement, Streetscape, Utilities, Construction, Landscape, and Storm water.

Despite this emerging literature, the uptake of innovative and sustainable design practice is rare, largely due to a lack of local financing for maintenance and replacement. The difference between the current state of repair of infrastructure and the stated acceptable condition is commonly referred to as the "infrastructure deficit". In Canada, annual infrastructure spending by the federal government accounts for $2.5 billion, the provinces $4.0 billion and local governments $7.7 billion. However an estimated $40

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[21] http://www.cardiff.ac.uk/archi/programmes/cost8 accessed June 06

[22] http://www.infraguide.ca accessed June 06

[23] http://www.nyc.gov/html/ddc/html/ddcgreen/reports.html accessed June 06

billion plus is required to repair infrastructure systems to an acceptable level of performance: for example, water distribution $6.1 billion, water treatment plants $4.3, billion, sewage collection $4.6 billion, roads $8.7 billion, bridges $0.8 billion, and solid waste facilities $0.8 billion. [CICA] If adequate financing for replacement is considered, the deficit is much greater.

A majority of new urban growth in Canada has no life-cycle costing or reserve funding.[24] It is a gamble. Cash-strapped local governments simply hope that the future income from property taxes – the principle source of revenue for cities in Canada – will be sufficient to cover both the on-going maintenance and eventual replacement cost of aging infrastructure.

Existing infrastructure systems also face threats from rising population densities. While higher densities are generally positive from a sustainability perspective, the challenge is to build within the constraints imposed by both the natural and the built environment. Higher density can mean that water pressures become inadequate for fire fighting. Increased truck traffic can mean that road bases fail prematurely. Infill development can mean impermeable surfaces and overloading of storm water drainage and water treatment systems. Thus the intensification of land use that may be naturally occurring within growing municipalities can threaten the long-term functions of existing critical infrastructure.

Surprise as a by-product of complexity

Surprise is a characteristic of complex systems. Linstone, in his book on *The Challenge of the 21st Century: Managing Technology and Ourselves in a Shrinking World*, uses an ecological model to describe the important role of surprise in the evolution of complex systems. (Figure 49) As systems move from centralization to decentralisation, and from varying levels of separation (differentiation) and combination (integration) a system evolves through alternating phases of order and chaos. Using Linstone's graphic, it can be argued that current infrastructure is moving from the lower left (centralised and isolated systems for storm water, potable water, waste water and so on) to the upper right quadrant (decentralised and integrated) In the process, surprises are bound to occur. "For complex systems, disorder is as normal as order and everything interacts with everything. Thus the prediction capability of science and technology is constrained, and so, too, is our imagination. Surprises will therefore be certain in our future." [LINSTONE 94] He describes the 'surprising surprises' as the ones that cast no shadow.

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[24] Personal discussion with staff at Infracycle Software, and municipal planners across Canada as part of preparing a draft InfraGuide on Integrated Infrastructure design.

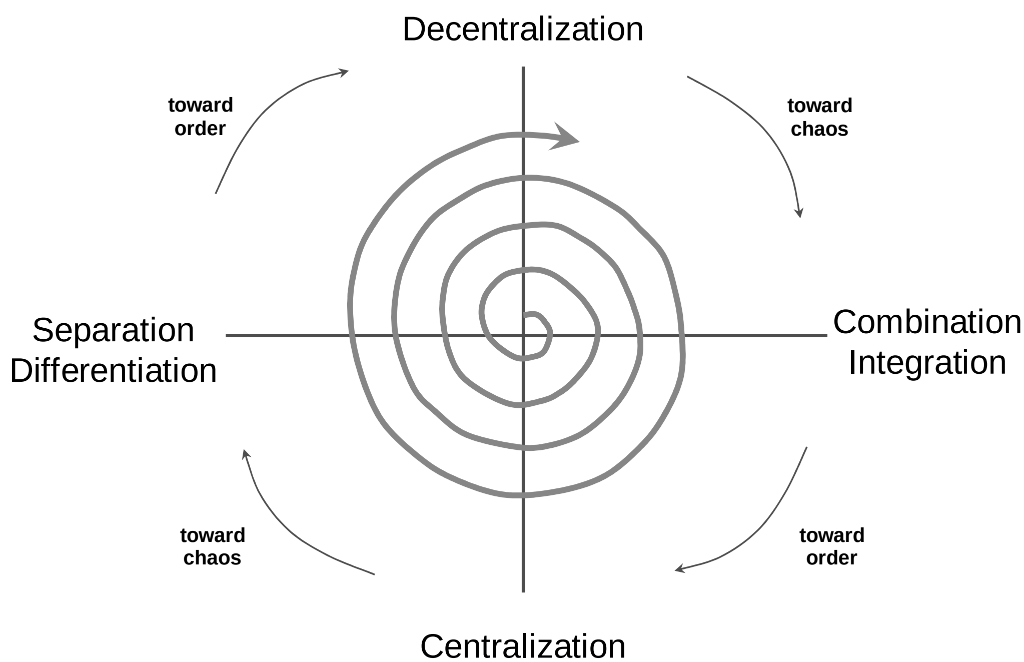

Figure 49 If centralised and separate infrastructure systems transform into a distributed and integrated networks, some degree of chaos may be inevitable [Adapted from LINSTONE 94, redrawn by author]

Complexity, with its element of chaos, is thus part of the evolutionary process. It is double-edged. It can contribute to long-term resiliency because the added redundancy and diversity provide a larger number of options when the system must adapt to new conditions. At the same time the many indirect consequences of actions become obscure, and this undermines efforts to control or predict system behaviour, and achieve key goals and targets. All well-managed systems – even those based entirely upon incentives - require some understanding of cause and effect relationships in order to set the rules. Nowadays the cause and effect chains are many and long, and understanding key connections often impossible.

Engineering of urban systems is based upon establishing fixed parameters and then achieving a reasonable margin of safety for the design element within a controlled situation. Essentially any surprise is assumed away. This is exactly wrong when designing complex systems. As Lovins explains, one way that engineered complexity can lead to surprise is by causing many supposedly independent and redundant components to fail at the same time for unforeseen reasons. [LOVINS 82]

In 1998 the 'leaky condo crisis' in Greater Vancouver became a tragedy for tens of thousands of homeowners and qualified as a national disaster, with direct economic losses of $1 billion and indirect costs of $2 billion. The premature failure of buildings was largely a reflection of the increasing complexity in the built environment. Over the course of a single decade the predominant forms of new housing morphed from simple, single-family homes with peaked roofs and large overhangs to complex California-style flat-roofed condominiums with no overhangs. This change in consumer preferences and housing styles was paralleled by a rapid proliferation of new building materials such as oriented strand board (OSB), which are inherently more vulnerable to moisture damage. Unforgiving exterior veneers such as face-sealed acrylic-based stucco made it difficult for cavities to dry out once wet. Ventilation of cavities was reduced by energy-efficient construction and by replacing vented heating appliances with resistance electric heating. Increasingly convoluted architectural detailing was much more demanding to install and to seal. [MORRISON 96] [CONCEPT 06]

The ensuing increase in building failures – the leaky condo crisis - was difficult to predict because of the complexity of contributing factors. The complexity of the cause and effect chains, and the initial failures in the new building typologies, need not have escalated into a crisis, but the local system was not designed to anticipate or respond to surprise. The changes to standard construction methods were occurring rapidly and thus the result was surprising to everyone. The province had no building research budget and therefore no way to evaluate local conditions and problems; nor was there any routine monitoring of building performance to enhance learning, or to sound the alarm. Design professionals and contractors were untrained in the physics of building science, and unprepared for any type of failure scenario. Building trades in the residential sector were not part of any ongoing communications and learning process. For all these reasons the crisis was impossible to either detect or correct in a timely fashion. Exactly the same disaster was later created in other growing cities with similar climates and cultures - for example Seattle, Washington and Auckland, New Zealand. According to Gunn, the recurrence of disaster scenarios in multiple locations is a familiar pattern for 'unnatural' disasters. [GUNN 03]

Surprise is also to be expected when humanity interferes with complex natural systems like farms, forests, and fisheries; or the complex atmospheric systems that control climate and air quality. A history of stability within complex systems can be misleading because of the many gentle buffers - or negative feedback mechanisms - that ecological systems use to mitigate stress. As humanity pushes natural systems into uncharted territory, eventually we cross thresholds (tipping points), experience positive feedback, and encounter sudden discontinuities such as species collapse, invasion by new species, infestation, fires, floods, and climate change. [REES 01]

6.2 A Long-term Approach to Security by Design

Police, rescue services and other first responders have little influence over land use patterns, building physics, resource flows and circulation patterns. Nor can they model – with few exceptions – the security and resiliency of alternative urban system designs under different hazard scenarios. Thus most city emergency planners assume a reactive approach that emphasises preparation by responders only, and that addresses exclusively short-term response and recovery for critical support systems.

Extended time scales make possible a great number of design solutions which are rarely or never considered by conventional teams of emergency planners. More specifically, it becomes possible to reduce vulnerability of the long-lasting elements of the urban system – buildings, roads, critical infrastructure systems, culture and institutional structures. Mileti concludes that long-term thinking is fundamental to the success of mitigation strategies – "by far the broadest and most potentially effective of all the strategies available under the current paradigm". He concludes that the current approach to mitigation is too short-sighted. "In general people have a cultural and economic predisposition to think primarily in the short term." [MILETI 99]

The long-term approach introduces a different set of design tools and methods as illustrated in Figure 50. The shorter-term time rings encompass the traditional tools of mitigation, response and recovery. As we move to the longer-term rings it becomes possible to develop a culture of preparedness, to implement resilient design, and to map the risks and apply local intelligence. Each of these long-term methods is explored in the remainder of this chapter.

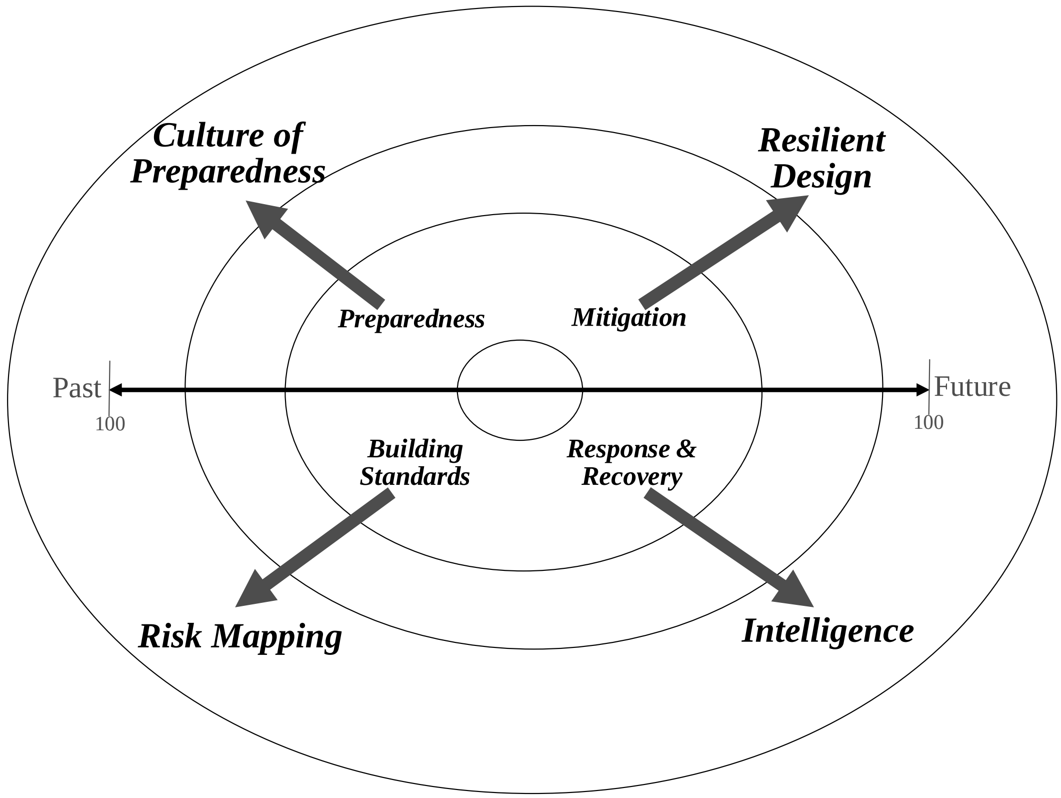

Figure 50 Time extensions produce an expanded set of strategies for resilient urban regions

6.2.1 A Culture of Preparedness

If urban regions are now vulnerable to an increasing range of threats, is their capacity to adapt becoming a question of survival? If so, it may be necessary for regions to develop a 'culture of preparedness' that makes security and survivability part of their identity. For example a culture of preparedness might be a narrative that emphasises the capacity of individuals and local groups to overcome obstacles, to learn, adapt and prosper in the face of adversity and change. Such narratives can create expectations and determine behaviour. They provide one method for making shocks less threatening, surprise less of a crisis.

For a culture of preparedness to be truly effective over the longer-term it would need to enhance the capacity for individuals and local institutions to continuously learn and adapt. Such capacity may be integral to sustainable system design. To better understand what this may look like, it is necessary to examine the rich discourse by academics and educators on what might constitute lifelong learning and the 'learning society'

Revitalising the Learning Society

Lifelong learning is a concept that has had four broad and mutually supporting objectives: personal fulfilment, active citizenship, social inclusion and employability/adaptability. [EU COMMISSION 02] Learning is usually taken to refer to all modes: formal, non-formal and informal. In recent years the attention on lifelong learning has been stimulated by globalisation, the new information technologies, and changes in family structure and demographics. The greatest attention is now given to workforce competitiveness. Increasingly the changing nature of employment requires that communities support training for individuals so that they can accumulate transferable skills for the changing labour market. In this narrow sense, a learning society is capable of re-training adults so that the local economy can remain competitive despite globalisation.

The emerging concerns over urban security may help to reinforce some of the earlier theories underlying the ideals of a 'learning society'. The term learning society was first promoted in the late 60s and 70s by writers such as Robert Hutchins (*The Learning Society* 1968), Donald Schon (*Beyond the Stable State, Private and Public Learning in a Changing Society* 1971) and Torsten Husén (*The Learning Society* 1974). At that time the focus was on active participation by adults in community life - creating a 'learning democracy' in which all citizens could improve themselves and add value to the whole community. Better educated citizens could participate in critical discourse and help to shape agendas, examine services and vote intelligently. The ideal of a learning society was partly a reflection of increased wealth and leisure time, and partly a response to the rapid changes in technology, knowledge and values.

Donald Schon argued that technological change is uniquely disruptive to stable views of occupation, religions, organisation, and value systems. He proposed that institutions develop capacity to bring about their own transformation by means of 'learning systems' – systems that are flexible, lack apparent structure, have no fixed centre, and have overlapping networks and feedback loops. [SCHON 71] He went on to develop new theories of learning suitable for a learning society, including 'double-loop learning' – a process of change which can involve modification of an organization's underlying norms, policies and objectives". [ARGYRS 78]

Many early proponents of lifelong learning felt that the formal institutes of learning should no longer enclose learning; rather learning should become a process integrated within every day life. Husén felt that educational problems in a rapidly changing society are too important to be left entirely to educators. [HUSEN 74] Ivan Illich, writing at the same time, argued for de-schooling society, replacing institutions with learning webs, skills exchange, peer matching and a flexible network of learning opportunities. [ILLICH 71]

So what has changed since the 70s? Certainly the focus on competitive economies has gained central stage as communities everywhere are threatened by global markets that are rapidly changing and often difficult to predict or control. However the original stimulus for a learning society is just as valid today as in 1970. In fact the arguments have grown immensely. Not only has technological change become a constant challenge, but the pace of change is accelerating. Information technology has opened up many new opportunities to engage adults and whole communities in learning networks. The necessity for institutions to adapt and continuously improve is greater than ever in a globalised marketplace. The number and size of communities has grown exponentially, and so have the diversity and frequency of threats. The current levels of environmental destruction and massive poverty may require changes to society norms (new time concepts, for example) and adoption of new mind sets like sustainability.

Thus from the perspective of security and adaptability, a strong case can be made for revitalising the ideals of the learning society and making them a central component of how urban design is carried out, and how urban infrastructure is constructed and maintained. The overlapping networks, learning webs and feedback loops for information proposed by Illich can be seen as social infrastructure, something that can be designed according to the same principles as all other sustainable urban systems.

Patrick Ainly has examined the learning society from the perspective of information theory. He points out that all thermodynamic systems – physical, biological and social – involve exchanges of information -or energy – in order for the systems to be self-sustaining. He argues that energy and information can be viewed as synonymous from the perspective of system design. Simpler systems are open to control by the larger systems that supply the energy or information necessary for their continued operation, survival or reproduction. Ainly argues that the information structures for life systems are the cells, organs, bodies, societies and species that make up the biosphere. The circulation of information within these life systems is determined by the 'finality' or purpose of life (i.e. they are syntropic). Within life systems people can be seen as 'self-steering' sub-systems, capable of learning from past mistakes and acting differently in the future. Part of the challenge is opening up these individual learning sub-systems, so that they can better guide the larger systems towards satisfy societal goals. Thus information theory describes a learning society as a way to enhance information control systems, something that is obviously important at a time when society is seeking to become more self-sustaining.

Ainly recognises that the priorities have changed and that the central issue for a learning society is now learning to survive: "The fist priority for any government seriously committed to real modernisation would be to re-establish the central purpose of education, science and the arts in society: to stimulate thought and develop new knowledge and skills to deal with a rapidly changing reality. This would be a real cultural revolution – not the partial 'skills' and 'enterprise' revolutions limited only to vocational preparation and individual competition. Nor would this new learning policy present itself only as learning for leisure. Cultural production is essential…. to encourage the restoration of the environment that the destructive productivisms of the past have already gone so far to destroy." [AINLY 98]

Stewart Ranson writing in *Inside the Learning Society* describes the importance of cities and urban regions as key players in a learning society. [RANSON 98] He points to initiatives such as the *European Educating Cities Movement* and Briton's *Learning Cities* movement, and argues that the city offers a focus for a powerful learning culture based on common needs and shared history – something that is much less likely to emerge at a larger scale. The city is also in a good position to provide leadership and coordination for learning activities - the physical and social 'infrastructure' for learning networks. Finally, he states that at the city level, learning can be well integrated into community action and active citizenship.

Based upon such arguments, security for urban regions may require that the learning society become the larger context for urban system design processes. Citizens, businesses and organisations involved will need the capacity to collect information, to assess risks, to work collaboratively, and to adapt and respond continuously. If there is to be such a 'cultural revolution', as Ainly suggests, what are the implications on the design process, and on the adaptive capacity of the region's institutional structures? One possible source of inspiration for design of such structures may be to examine ecological models for adaptive management.

Adaptive Management for Urban Systems

The concept of adaptive management emerged in the ecological sciences and provides a model for coping with complex systems and surprise. The high degree of uncertainty and unpredictability in managed ecosystems means that surprises are inevitable. The solution is active learning – a process referred to by Buz Holling as 'adaptive management'. [HOLLING 78] Adaptive management is an integrated, multidisciplinary method for natural resource management that addresses learning and flexibility. It is adaptive because it acknowledges that the natural resource being managed will always change and therefore humans must respond by adjusting and conforming as the situation changes. From this perspective all policies must be viewed as hypotheses, and be designed for flexibility. The learning capacity and flexible designs become 'sources of novelty' that help to transform systems so that they adapt to surprise. [GUNDERSON 02].

Mileti has proposed a more adaptive approach to hazard mitigation that also emphasises the importance of societal learning. He argues that "Hazards mitigation must become a process fed by the continuous acquisition of different mixes of new knowledge from different fields. Human adaptation to hazards must become just as dynamic as the ever-changing problems present by hazards themselves." [MILETI 99] He proposes that a 'sustainable hazard mitigation network' be created within each urban region, to engage in community in collaborative problem solving. "Each network would produce an integrated, comprehensive plan linking land-use, environmental, social and economic goals. An effective plan would also identify hazards, estimate potential losses, and assess the region's environmental carrying capacity. … This kind of holistic approach will also situate mitigation in the context of other community goals that, historically, have worked against action to reduce hazards." Mileti suggests that an approach is needed to forge local consensus on disaster resiliency and nurture it through the complex challenge of planning and implementation. Mark Pelling also argues for collaborations and partnerships as an essential ingredient in creating 'social resiliency' and in vulnerability reduction in cities. [PELLING 03]

Ideally adaptive management systems reduce the confusion and costs associated with change. To this end, planning processes may need to engage many more participants in order to quickly build a constituency for making difficult decisions, and to allow decision-makers to tap the creativity and knowledge of the entire population. Decision support systems may be needed that reduce barriers stay informed, that facilitate multiple scenario analysis, and that translate the knowledge of experts into language and images that can be understood and appreciated by experts in other fields, and by decision-makers, residents and people in other locations. What is not clear is how such systems might be integrated into forms of governance within urban regions.

6.2.2 Resilient Design

Resiliency is a concept that is traditionally used to describe two characteristics: the *robustness* of a system – i.e. its ability to continue to perform by resisting changing conditions, and the *adaptability* of a system – i.e. its ability to continue to perform by responding appropriately to changing conditions. Resiliency can be used as a potential design criterion for all urban systems including built infrastructure, culture and governance.

The term resiliency can mean different things depending upon context and formal training. From a traditional engineering perspective, a system is resilient if it continues to function within a narrow band of acceptable performance. Some systems are more robust than others. The key determining variables are illustrated in Figure 51, where a system is shown to deviate temporarily from the optimum performance. [REDMAN 99] The degree of deviation (resistance), the amplitude of change (severity), and the speed of correction (response) are all factors that influence the time to recover and the total system loss or cost resulting from the perturbation. The objective is to minimise the return time to a single global equilibrium.

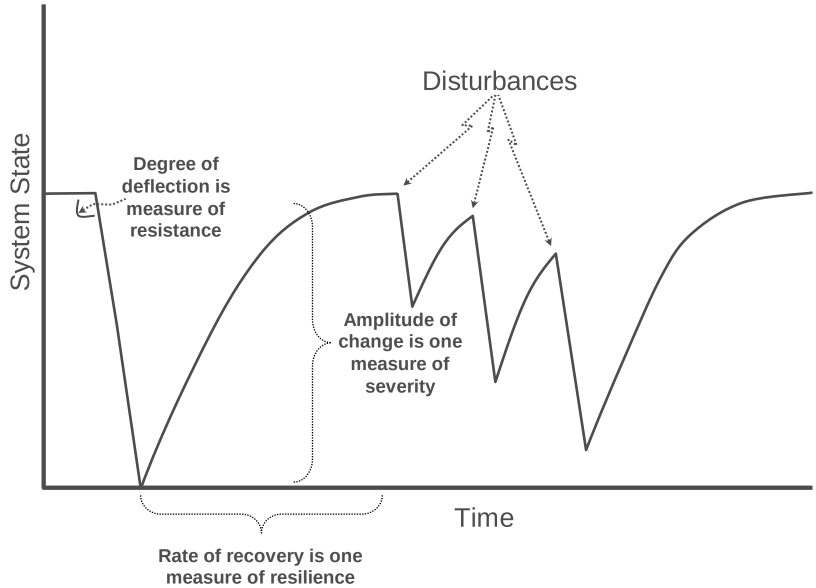

Figure 51 A model of how a system state changes with disturbances and yet fully recovers [adapted from REDMAN 99, expanded and redrawn by author]

From an ecological perspective, where extended time horizons and complex systems are the norm, the concept of resiliency assumes a more cyclical pattern. From this perspective, failures in the system are inevitable sooner or later. Resilient systems are those capable of re-establishing their full functionality and potential within an acceptable period of time

Adaptive Capacity

The concept of permanent change in state for systems is familiar to ecological scientists because many types of complex living systems (ecologies) under stress have been observed to flip into entirely new stable states. A familiar example within Canada would be the east coast cod fishery which was once possibly the most productive fishery in the world. Over-fishing now appears to have permanently altered the species mix and productivity of the system, and despite the continued availability of environmental resources the cod are not returning. The cod fishery collapse is just one of many collapses worldwide, including Atlantic halibut, Atlantic blue fin tuna, Atlantic swordfish, North Sea herring, Argentinean hake, and Australian Murray River cod. Ecological scientists like Jared Diamond and Lance Gunderson have documented many examples of altered states that defy efforts to re-establish prior performance. [DIAMOND 05] [GUNDERSON 02]

Figure 52 illustrates the concept of alternative stable states as defined by Gunderson and C.S. Holling. The troughs represent the stable performance conditions, the hills are the negative feedback systems that help to return the system to a state of equilibrium; the peaks are thresholds that can direct the system into new troughs. Engineering resiliency is represented by steep slopes on the sides of the cup; ecological resiliency is represented by the width between peaks. [GUNDERSON 03]. Push too far, some systems may never recover, and instead stabilise in an alternative configuration – a transformative failure. Less resilient systems are thus at risk of a permanent loss or change in performance. More resilient systems have more tolerance for movement without permanent loss, a characteristic referred to as 'adaptive capacity'.

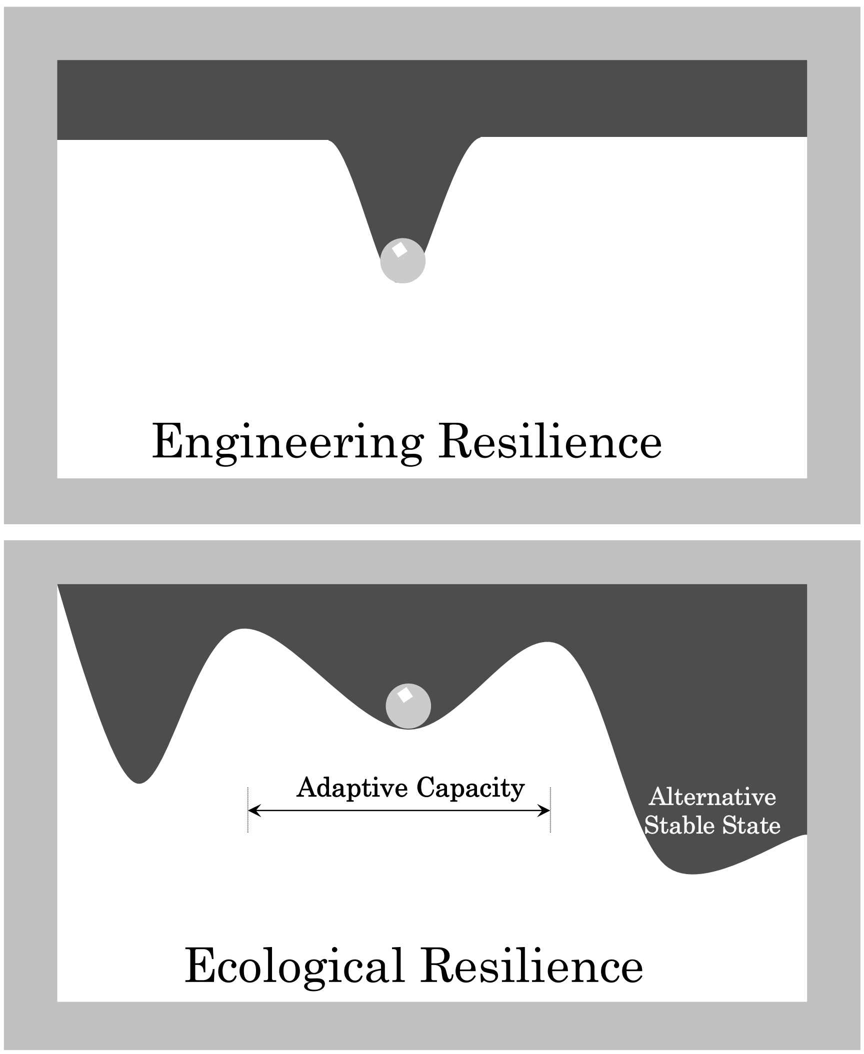

Figure 52 Engineering resiliency achieves desired levels of performance by keeping the system within narrow bounds (the steep slopes) but

at a loss in flexibility; ecological resilience allows for substantial change in system performance (the distance between peaks) and thereby reduces the risk of flipping into an altered stable state [GUNDERSON 02, redrawn by author]

Working with a very broad cross-section of scientists, Holling has explored adaptive capacity as it applies to many large scale living and built systems. [HOLLING 01]   Figure 53 reproduces and explains the heuristic that he and his colleagues have used to define resiliency and the cyclical process of disaster recovery that is a feature of all long-term ecologies. The dynamics may offer insights into design solutions.

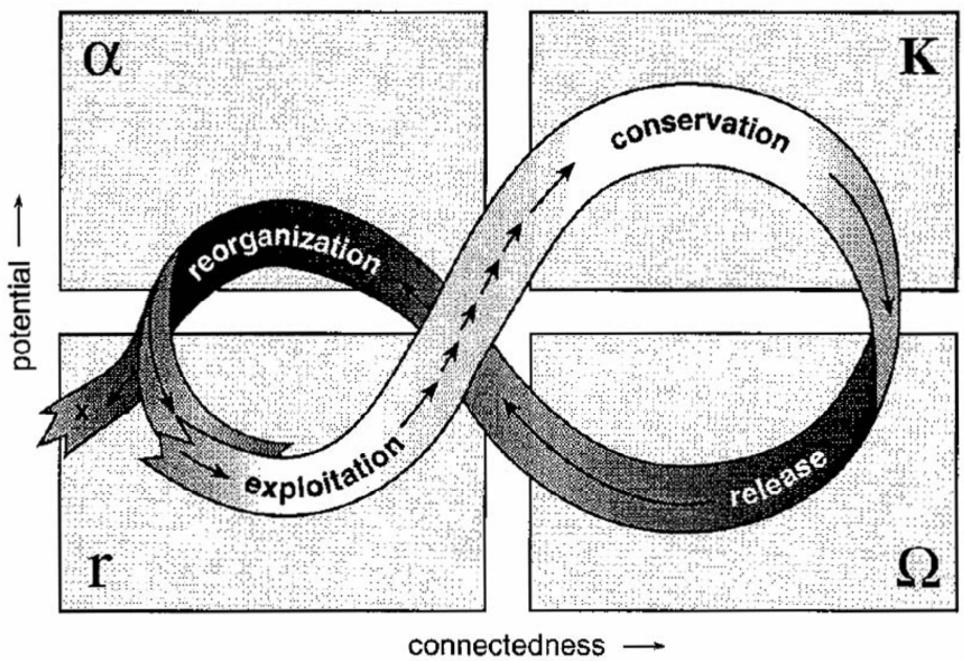

Figure 53 The Four functions of an adaptive cycle can be applied to any complex system design. "Short, closely spaced arrows indicate a slowly changing situation; long arrows indicate a rapidly changing situation. The cycle reflects changes in two properties: the y axis (the potential that is inherent in the accumulated resources of biomass and nutrients) and the x axis (the degree of connectedness among controlling variables). The exit from the cycle indicated at the left of the figure suggests, in a stylized way, the stage where the potential can leak away and where a flip into a less productive and less organised system is most likely." [HOLLING 01a]

The most important element in maintaining diversity is what Holling refers to as "the keystone structuring processes that cross scales". Most ecologies appear to rely upon just a handful (fewer than six) keystone species to maintain and restore system health. These species always have order of magnitude differences in lifetimes, moving through the time rings described in Chapter 3. The temporal diversity contributes to system "memory", as any gaps are more easily filled by neighbouring species, through a process of regeneration and renewal.

The ecological model also suggests that by forcing a system to perform within narrow boundaries for too long, the result can be a catastrophic loss in performance and a permanent flip into an alternate – possibly less desirable – condition, as described earlier.

Other writers have also attempted to derive principles of resiliency from the science of ecology. Levin cites five examples: modularity and compartmentalization protect systems against cascading; redundancy; local control over resources; and retaining critical resources for both your own and the community's survival (the law of reciprocal maintenance). [LEVIN 99] In his book *The Vulnerability of Cities – Natural Disasters and Social Resilience* Mark Pelling defines resiliency as a proactive stance towards risk, drawing on ecological theory and systems analysis. He cites six principles of resiliency, developed originally by Aaron Wildavsky, including: homeostasis – feedback signals which enable learning; omnivory – a diversity of resource sources and supply routes; high flux – rapid distribution of resources to copy with perturbations; flatness – a non-hierarchical system of decision-making that allows for flexibility in the face of surprise; buffering – capacity in excess of needs; and redundancy – allowing for vital functions to be satisfied through alternate means. [PELLING 03]

Translating such principles to urban region design is fairly straightforward. Modularity is simply another way of describing the distributed systems and self-reliant urban villages imagined in Chapter 7. In fact elements of resilient design appear to reinforce a number of the localised multi-functional technologies that are promoted for increased efficiency. Remote generating plants, incinerators, treatment plants and communications facilities are far more vulnerable to catastrophic failure than a network of modular, distributed systems, closely integrated into the fabric of the city. Thus urban security helps to reinforce design strategies for urban resource efficiency and environmental sustainability.

Redundancy may mean that urban systems acquire the capability of drawing resources from as wide a geographic area as possible, in the eventuality that droughts, floods or other disasters affected any one area. For each type of critical resource, the region may develop redundancy through a diversity of supply options, or through a contingency plan. Redundancy for agri-food systems, for example, might encourage trade in basic food commodities with at least two separate regions, while maintaining plentiful agricultural land in the valley as a back up.

Redundancy may also need to consider the entire supply chain for each critical commodity, all the way to the end ecological resource. Redundancy can then be provided for the weakest links in the chain. Links are the processes or 'nodes' that provide essential services, wherever they are located. When we discover nodes that are essential, but not duplicated elsewhere in the system, we have found a weak link. Redundancy and self-reliance work on different scales. Even links within the region can benefit from contingencies. For energy systems, for example, this may mean a mix of sources, some local and some renewable. For potable water, this may mean distributed reservoirs.

Local control allows for self-organising systems that do not require lots of external regulation or direction in order to function or adapt to opportunities or constraints. Such systems operate by a set of rules, similar to the market place, rather than a mechanistic, top down approach that imposes a final solution from start to finish. A familiar example in urban regions are the Internet Service Providers (ISPs). Their location, ownership, pricing, scope of services and level of integration with other communications services is still a very fluid and self-organised process. The potential for similarly distributed and intelligent organisation is likely to rise as the intelligence systems themselves become integrated into manufactured products and other elements of the constructed environment. [KELLY 94] Will self-organising systems become the most efficient and adaptable model for all infrastructure systems during a period of rapid change?

Adaptability and durability

Adaptability can be broken down into a number of simple strategies that are familiar to most designers: flexibility or enabling minor shifts in how systems function or spaces are used; convertibility, or allowing for changes in use for parcels of land or buildings, or changes in inputs for infrastructure systems; and expandability, or facilitating additions (or deletions) to the quantity of land or space dedicated to particular uses. Buildings that are design to survive change, at a low cost, are likely both to survive longer, and to operate more efficiently throughout their lifetime. Rough estimates suggest it may be possible to reduce life cycle impacts by as much as 30%, by incorporating foresight in design [RUSSELL 01]. Presumably the same arithmetic works for urban systems, since they can have even longer-lifetimes.

Durability is a concept that can further extend the useful lifetime of materials and technology, and is complimentary to adaptability. In practice adaptability and durability can be achieved through changes in design, and through the use of alternative zoning, materials and technologies. For high performance, adaptable designs might begin with the concept of a fixed investment cost. The object is then to achieve maximum durability by means of flexibility and adaptable design features, while at the same time minimising the running costs for energy, cleaning, maintenance and operation. The solutions are likely to focus on low impact cleaning supplies, solid reliable components, and simpler designs, rather than the more complicated solutions that optimize running costs and investments but fail to adapt over time. Part of a durable design strategy may be to set minimums, for example no secondary components that last less than 30 years. In other cases the solution may be to minimise maintenance and service costs for components.

A number of approaches have been promoted for extending the useful lifetime and minimising the costs of change at the building scale. The *Open Building System*, promoted by Frances Duffy of the DEGW, addresses commercial space in four discreet functional layers of longevity, each with a different lifetime. [DEGW] Stewart Brand has used this approach to create a more generalised set of temporal rings, which he describes as being in constant contact with one another, creating "shearing layers of change". [BRAND 94] His conceptualisation of time rings for building design does not transfer well to the urban region where so many additional layers and interactions are possible, including the time constants for ecologies, open space, transportation systems and so on. Considerable work may be needed to extend such adaptability models to the urban scale.

Canada Mortgage and Housing Corporation has promoted a set of broad rules for adaptability in constructions. The rules are intended for all stages of a building project, but in this case appear to be transferable to infrastructure and design projects at virtually any scale. Their rules or principles of adaptability, drawn from case studies and the literature, include: design for versatility; design for durability; plan for easy access; favour simplicity; factor in redundancy; allow for upgrades; opt for independence; minimise destructive change; and make important information (e.g. warranties, commissioning) explicit. [CMHC 97]

According to Gharajedaghi "modular design is the most potent and practical means of handling change and implementing complex design, without getting lost in the process." [GHAR 06] The smaller sub-systems operate as independent systems, with the ability to be relatively self-controlling, and yet act as responsible members of a coherent system with the ability to respond effectively to the requirement of their containing whole. Compartmentalization and modularization help to reduce the vulnerability of systems to the failure of any single part. Modular design also allows sections of a system or of a building to be upgraded or replaced without affecting the connected systems.

The deep uncertainty encountered beyond a 30-year horizon makes it especially difficulty to design for adaptability. Consider for example a designer 37 years ago, who was trying to make a new, 1965 building intrinsically more adaptable. Would the designer have had the foresight to facilitate such activities as: Removal of asbestos insulation from all the pipes and ducts? Installation of extra ventilation for computer rooms? Retrofit of larger window areas? Installation of increased electrical outlets and plug loads? Installation of natural gas, district heating pipes, rooftop solar water heating and PV panels? Relocating the fresh air intakes to avoid toxic street pollution? Accommodating much higher occupancies, and demands for improved individual comfort and environmental controls?

None of these specific activities would have been predictable in the 60s. Long-term forecasts are probably even less helpful today. This points to the difficulty in conducting long-term assessments of costs and impacts for any system design. Unless a system is capable of responding to change, it is vulnerable to becoming poorly utilized and prematurely obsolete, with a corresponding increase in the life cycle costs. And yet it is very difficult to predict potential changes or threats, and the extent of vulnerability. A method is needed for augmenting life cycle assessments (LCA) with an evaluation of how well a design will perform within multiple, plausible future scenarios, including significant change.

William Fawcett and Ian Ellingham have proposed that issues of uncertainty be dealt with more explicitly within the financial models used for building maintenance and renovation. [FAWCETT 2000] They propose to borrow methods from the financial markets, where uncertainty is addressed through 'options' (calls and puts) that can be embedded in the investment scenarios, and that recognise that most investments have the effect of creating or extinguishing further investment decisions. For example, a decision to retrofit today precludes waiting another year, and making the investment decision when specific uncertainties –such as fuel prices or tenant requirements or new technological solution – may become more certain. Thus the option of waiting may have some real benefits in terms of risk management. When options are used in decision-making outside the financial sector, they are referred to as 'real options'.

Real options provides a way of incorporating both time and uncertainty into life cycle scenarios, since any scenario can incorporate a range of expanding options over time, reflecting the changing flow of information available to the decision-maker, and the changing circumstances encountered by the building or system under question (life-time of components, user needs, etc.). Figure 54 contrasts the simple binominal scenarios used in conventional life cycle costing with an options approach, where a spreading tree of options creates multiple scenarios and a much more detailed accounting of the actual uncertainties and associated risk. According to Fawcett et al, the many options can be integrated into financial calculations, using market-established values for risk, and help to clarify the real cost of uncertainty in managing building stocks. They further argue that even if the financial calculations are not employed, the options approach provides decision-makers with a better conceptual model for addressing life cycle costs.

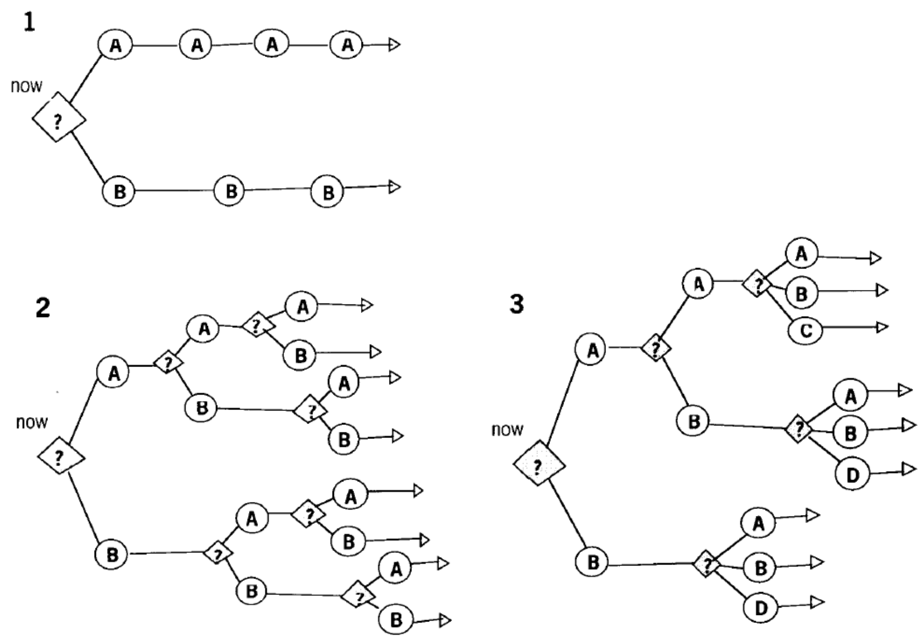

Figure 54 Three time-sequence diagrams illustrate different approaches to addressing uncertainty in life cycle investments: (1) is a traditional approach where decisions today are simply extended into the future; (2) an approach where new decisions between the same alternatives become possible at future dates; and (3) an approach where multiple alternatives emerge at specific times in the future

The real options approach appears to suffer from difficulties common to most financial-based models for decision-making. Discount rates are used to convert future options into present values – an approach that appears to have fundamental flaws. No effort is made to incorporate the many other external or indirect impacts of investments in energy efficiency, such as worker productivity, local air quality, occupant comfort, corporate good-will, and so on, all of which are similar to the real options in that they can easily change the net benefit/cost. An even more fundamental difficulty is that the future is assumed to contain only knowable risks, which does not represent a complex world where sudden surprising surprises can affect not only the performance of systems, but the capacity of the decision-makers.

Try to purchase a small emergency generation system for your building after the ice storm has already occurred. Many investments offer a degree of insurance against the unexpected because they enhance the inherent resiliency of the system.

To some small extent, the capacity to survive unexpected changes is implicit within existing LCA methods that help to integrate some of the operating costs into the overall investment decisions. A building that is less polluting is probably less reliant upon resource inputs and inherently better suited to a future where prices are unknown, where resources may become scarce, and where buildings may become subject to stiffer environmental regulations. Low impacts equal lower demand and lower risk. However even low impact designs are vulnerable to changes in use, social values, lifestyles, technology, and sudden shocks. Is it possible to standardise an approach to measuring the capacity of a buildings and urban systems to survive change?

One approach is to assess whether measures have been taken to adapt to known trends, and those changes that are highly probably over the near to mid term. An example might be a system that is designed to withstand expected changes to regional climate such as increased storm intensity and storm water peak flows, more extreme temperature events, higher sea levels, and droughts. Responding to these trends through adaptive design is prudent if the costs of redesign are significantly less than the estimated risk of loss.

Another approach is to examine the 'survivor buildings and fragments of old towns' within cities today, and establish an empirical 'checklist' of features that appear to make buildings and systems inherently more adaptable, whatever the future. "…in a loose way, assuming that future changes are likely to be roughly similar to past ones, we can look to see what historical conditions have allowed subsequent change to occur more easily." [LYNCH 93] Hassler and Kohler point out that the great diversity of existing building types and ages provides a sizable population from which to derive lessons on adaptability [HASSLER & KOHLER 01]. Survivor buildings tend to emphasise the benefits of natural lighting, tall ceilings, accessible utilities, fail-safe moisture-proofing, generic sizing of rooms, regular spacing of structural components, long-lasting veneers, and extra load-bearing capacity. [BRAND 94]

Lynch sites excess capacity in terms of space, pipes, structure and foundations, and especially critical infrastructure such as water reservoirs. He also sites generous communication facilities for cities – including sea and land connections. He advocates modularity, at all scales, including the potential for separating columns from non-load bearing walls, residential units from commercial, and roads from rights-of-way: "The ideal city plans that, in the name of adaptability, propose a mega-structure of transportation channels, within which building elements may come and go, forget that transportation is only one of the more rapidly shifting urban technologies. Rights-of-way are quite likely to have a long-time usefulness, but specific types of roads do not. The designers may have separated and fixed the wrong elements." [LYNCH 93]

While there is no guarantee that such 'adaptable' features will function similarly in the future, it is a reasonable default assumption. A bigger problem may be the likelihood of changing ownership, which removes most of the incentive to invest in features which confer value only at indefinite future times. Regardless, the first step is to create a checklist of features that can be used to encourage long-term adaptability as part of sustainable development projects. A second step may be to select a few core indicators that express aspects of adaptability. For example diverse buildings and systems provide a modicum of local expertise and acceptance should less favoured technologies and designs prove more appropriate over time. Diverse resource flows provide insurance against a sudden breakdown in supply chains. So too does deriving a percentage of critical resources derived from local sources.

One challenge is that the type of changes that will occur in the 21st century may be quite different than what has occurred at any time previous. Most notably, the transition to micro-technology has only just begun, and the nature of work and lifestyle is likely to be revolutionised. This raises difficult questions for the building sector. Is it possible, or even desirable, to adapt objects like buildings, with life times of decades, to IT techniques which change every three years?

Short-term adaptations of buildings to rapidly changing technical and social needs tend to be inefficient from a long-term perspective. There is a clear strategic difference between the short time management of buildings (optimal use) and the long-term, intergenerational management of building stocks and urban contexts (resource conservation). So the solution may not be to mould buildings to tomorrow's high technology. Rather architectural efforts must concentrate on those types of spatial environments that accommodate changing social and cultural norms, and that function well regardless of changes to the form of work and the types of communication technology. [KOHLER 98]

Whatever the approach to downstream accounting, the benefits of long-term thinking and resilient design are clearly evident within the built environment. So even if longer-term thinking about buildings does not extend the life of the building per se, it should help to optimise the life cycle costs and maximise the returns for society. Urban systems can perhaps benefit from adopting the more pragmatic strategies used by businesses to cope with change. In his book *Change Leadership as a Core Organizational Competency* Nadler argues that "The companies that survive in the coming decades will be those that are able to respond quickly and effectively to changing environmental conditions. This puts a premium on certain capabilities: adaptiveness, flexibility, and responsiveness."

For example adaptability may be enhanced through 'design for disassembly' - making it easier to take products, assemblies and systems apart so that their constituent elements can more easily be reused and recycled, or so that facilities can be adapted to new uses. It is also possible to reduce overall costs by purposely designing buildings and systems for a shorter life and disassembly. Similarly, it is important to avoid encapsulating or strongly interconnecting, short lifetime components with those having longer life times.

A key factor appears to be maintaining a suitable ratio of ceiling height to depth of rooms. This allows an incidence angle to keep interior spaces liveable and to allow for day lighting. Pre industrial buildings had to have such a ratio in order to maximize day lighting, and to dilute the combustion gases from oil and gas lamps. Thus 19th century construction works well today. Another strategy is to avoid complex design and back-up systems by reducing the sensitivity of the system to changes in supply scenarios. For example heating systems can be designed along thermal forces for circulation – so the building can "fly without engines". The design and mass of the structures provide a cooling time constant that will prevent the building from cooling more than 1 degree in 8 hours. Thus no back-up system is needed.

Kohler argues that ideally a building is sufficiently generic and flexible that it can solve for at least two uses out of five: school, housing, offices, retail and service. The additional costs for such adaptive capacity entail improved ventilation, acoustics, over-built ceilings, and larger lift options. If a building stock is made up of buildings that are individually more adaptable, it is reasonable to conclude that the entire stock is also more adaptable to change. For example, if a community experiences a sudden growth in population, the expandability and convertibility of existing buildings may contribute to relieving housing shortages at lower cost, more rapidly, and with less damage to the community character and urban fabric.

At the urban scale, adaptive capacity may depend upon the use of clusters and networks that mimic the cellular nature of an organism. District heating, cooling and power systems allow a neighbourhood cluster to quickly switch fuels, or install pollution control equipment, or upgrade to more efficient technology, or otherwise adapt with ease. For added security, the cluster can be networked with other clusters to share surpluses and provide back- up. Networks within networks achieve resiliency without undue centralisation of facilities. Since the formation of clusters and networks requires advanced planning and coordination, regional policies for adaptable land use and systems may need to underlie all other planning and design.

Despite these lessons from survivor buildings and towns, and the logical benefits of adaptable and adaptive design, urban systems are not currently subject to any evaluation of resiliency. Designers have very little guidance on how to improve adaptability, especially at the scale of an urban region.

6.2.3 Risk Mapping

Strategies for achieving long-term security can conflict with pressures to develop lands close to existing urban centers. In particular conflict can arise when trying to avoid risks from natural hazards and transportation corridors. Ideally high risk lands need to be inventoried, and addressed in a similar manner to areas that provide important environmental functions. The UN International Strategy for Disaster Reduction states that: "Deciding how to use land is demanding enough. It is even more daunting if there are competing views about the role that land should play in reducing collective exposure to risk. Consideration invariably revolves around whose land it is, whose risk is involved and most emphatically and who is to benefit. Too often, the desire for short-term gains override anticipated benefits that stretch further into the future. For these reasons, land-use management planning (at all jurisdictional levels) needs to be considered as a natural extension of conducting hazard assessment and risk mapping." [UN ISRD 01]

The integration of urban systems and disaster preparedness planning is complex due to the many locally-specific factors. **A National Mitigation Policy** was developed by the *Institute for Catastrophic Loss Reduction* and *Emergency Preparedness Canada* through a series of workshops across the country. The authors of the *Mitigation Policy* concluded that: "Local Action will be most effective. Communities need to make decisions about acceptable risks in their area. They need to have the capacity to manage their own environment and must decide what they are willing to risk in future disasters. ….Canada's vulnerability to the impact of disasters differs widely across the country. …There is no "one-size- fits-all" solution that can be applied equally across the country." [ICLR]

As an experiment the Canadian government geosciences division is now conducting *Pathways* - a multi-year case study to help communities in the Greater Vancouver area assess resiliency and identify security risks. [PATHWAYS 06] The study explores how best to incorporate geo-hazards into a formal urban planning context. A GIS and database software tool (Community Viz) has been used to assist with hazard susceptibility mapping and risk-based scenario modeling, for use in evaluating strategic urban growth alternatives and design standards. The object is to integrate the available scientific and geotechnical information into urban design exercises. The initial results of this process have generated a user and web-friendly tool for mapping risk. Figure 55 is an example of the risk surface for the Squamish Valley of BC, with respect to earthquake, slide and flood hazards. The Pathways research continues in an effort to integrate and monetarize these risks.

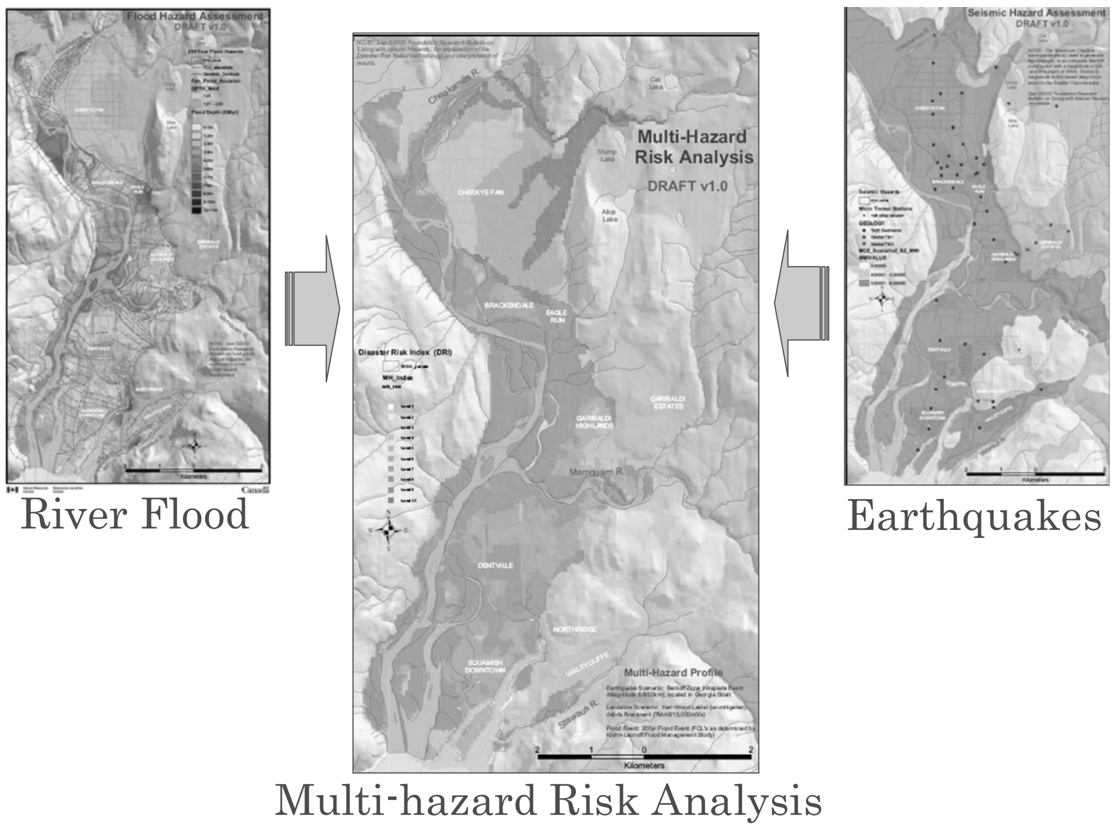

Figure 55 As a precursor to long-term system design, integrated risk mapping of Squamish District shows land subject to multiple hazards: flooding, earthquake and debris flow [NRCan Pathways 06]

Despite the wealth of new *Pathways* data now available to the urban planners in Greater Vancouver and Squamish, little response is evident. In fact the new urban growth plans for the area could be classified as high-risk.[25] The *Pathways* group expects to have more influence after they have fully incorporated economic costs into the risk assessment for urban growth scenarios. Ultimately they hope that a localised assessment of risk and

[25] Personal conversations with Pathways group staff Murray Journeay and Sonia Talwar, with respect to the Smart Growth on the Ground proposals for Squamish BC. June 2006.

costs, combined with the new visualization and assessment tools, will help to influence long-term urban design and planning. However given the extreme pressures for land development in growing communities, it is unclear why new tools and information – on their own - will be sufficient to affect land-use planning and development activity in the short or long-term.

Risk mapping and 3D visualisation of disaster scenarios may be a necessary precondition to long-term security-based land use plans. In some cases the result will be compatible land uses. In other cases, as with seismic regulations for construction, it may be necessary to develop building standards that reflect minimise vulnerability for the local risk landscape. In Squamish, for example, where flooding is a frequent and severe hazard, the solution in part may be to require flood-resistant buildings (e.g. lower floors are designed for submersion), and open space landscaping that minimizes the flood damage (e.g. green infrastructure, permeable swales and other detention systems). Perhaps the current proliferation of 'green building' standards can be customised to reflect the specific surface costs and threats.

Possibly the most ambitious approach to risk mapping has been conducted by the State of Gujarat, India[26]. The Gujarat State Disaster Management Authority, working with TARU, a GIS consultancy, is attempting to evaluate risk throughout the state and mitigate risk through more careful settlement planning. Web accessible hazard maps are now completed for earthquake, cyclone, flood, tsunami, and storm surge. At present such maps simply emphasise the extent of inappropriate land use development that is occurring. As Pelling argues, linkages between urbanization and disaster are weakly theorised and as a consequence disaster mitigation is rarely integrated into urban development policy. [PELLING 03]

6.2.4 Local Intelligence

A long-term proactive approach to external threats may require urban regions to invent localized intelligence services, collecting information on specific threats and vulnerabilities at all scales, alerting designers to necessary adaptation strategies, and developing alliances where necessary to mitigate or eliminate external threats. Local intelligence capacity is a reaction to the unprecedented and critical role of urban systems to the security of nations and individuals. It is also one reasonable response to the possible increase in diversity, frequency and specificity of threats.

Local intelligence might be designed along the same lines as other distributed systems, with nested networks and two-way flows. Within urban regions computer chips and sensors may be used to generate real-

[26] Examples of hazard mapping can be viewed at: www.gsdma.org/ (accessed April 06)

time data flows on system performance. For example the hydrology of a region can be monitored continuously, with public access to stream flows and ground water quality and quantity. The Edwards aquifer in SE United States[27], for example, has provided real-time data of stream flows on the web for many years. Ultimately a region can use sensors and internet communications to equip regions with the sensory equivalent of the eyes, ears and nose of a wild animal – allowing the systems within the region to independently detect threats and analyse choices.

A key function of local intelligence may be to share information between urban regions, offering sister regions an early warning system, and precedents and case studies of resilient design strategies. Many urban regions share similar topography and infrastructure, and can benefit from knowledge of successes and failures. In other cases regions may need to act in concert to minimize threats from hazards such as plagues or crime, and to implement effective mitigation strategies.

Aaron Wildavsky argues that the ability to predict threats – predictive capacity – requires large amounts of knowledge in order to know what will happen, when and how to prevent it. He is critical of any approach that relies exclusively on predictive capacity, and instead suggests that resiliency is more properly understood as a function of the resources a society accumulates from repeated experience with adverse consequences. He argues that "incessant trial and error" is what makes societies capable of learning how to survive. [WILDAVSKY 93] One difficulty with Wildavsky's argument is that the magnitude of hazard today may be too large to permit a trial and error approach; in such circumstances a precautionary approach may be warranted and this requires some measurement of predictive capacity. Moreover it is difficult to cleanly divide predictive capacity from resiliency per se. The ability to learn may be central to long-term resiliency, but the learning need not be confined to immediate 'trial and error' experience. Why can't society – or an urban region - examine a neighbour's experience, for example, and then adapt appropriate strategies to prevent or mitigate hypothetical losses? Historical patterns and future scenarios, used judiciously, may also serve as substitutes for direct experience. Thus predictive capacity is part of the intelligence that creates long-term resiliency.

Intelligence on External Threats

Any system for developing local intelligence on threats and vulnerabilities ultimately must rely upon the forecasting tools introduced and described in

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[27] Aquifer web site…

Chapter 3. Most forecasting exercises begin by identifying key driving forces that might impact the future of whatever system is in question. a handful of broad typical driving forces are examined, each of which is likely to have interact with others, and also impact the urban systems under examination. Keeping an eye on such forces, and responding accordingly, may be a key element of what distinguishes an 'intelligent' or responsive long-term approach to security for urban regions.

Part of what may now be needed is to standardise and operationalise such a procedure. A similar framework for intelligence may help regions share information, combine insights and learn from other's failures and near misses. The precise categorisation and selection of such driving forces needs to be based on practical concerns, and these may vary by region.

To date almost all long-term forecasting has been undertaken from an inter-regional or global scale, with no attempt to directly address the impact of driving forces on urban areas per se. An exception is "Urban Future 21: a global agenda for twenty-first century cities" in which Hall and Pfeiffer organise their analysis around three fundamental driving forces that they see as defining the key trends and outcomes for the urban world of 2025. [HALL 2000] The three forces are: Demographic Change, especially the growth of population in developing nations and the aging of developed world; the Changing Economic Base for urban regions, driven in turn by globalisation, technology and social change; and the Environment, including both degradation of life support systems and resource scarcities.

Their breakdown illustrates the difficulty of trying to keep a small number of forces. The extremely diverse categories of social, economic and technological change have been lumped together. Combining all environmental shocks and stresses into one category is more common, but belies the overwhelming impact potential of climate change on cities everywhere, which is already evident and which may exceed the impact of all other environmental forces combined.

Part of the challenge in establishing a framework for urban foresight is developing shared knowledge on how various forces have impacted urban areas historically, and on what changes are likely to occur in the coming decades. The historical patterns provide some measure of how sensitive different urban systems might be to particular external forces. The current trends help to determine which forces might have greatest relevance for contemporary urban design. For example, if we appear to be riding the steep part of a wave of technological innovations, then all the more reason to separate technology as a driving force in scenario planning for urban regions.

Another consideration is level of uncertainty around how forces might be expected to vary in their pace and direction of change. Economic forces tend to move much more quickly and erratically than technological, which in turn move faster than the cultural norms (world views). The pace of change within and between these different time scales is a key factor in understanding the impacts on integrity of whole systems, as described earlier in discussion on ecological time. In formulating scenarios, then, it may be important to explore how different combinations of forces are distributed across the 'rings of time'.

With sufficient knowledge of historical patterns, trends, and uncertainties for a range of forces it becomes possible to compare different forces in terms of how much they might threaten urban goals. The greater the threat, the more influence may be justifies when undertaking intelligence gathering and scenario development. As a foundation to urban intelligence, urban regions need to consider at least six generic driving forces: Technological change, Climate change, Demographics, Globalization, Resource Scarcities, and Shifting World Views. These clouds sit upon the time rings of a region, as shown in Figure 56.

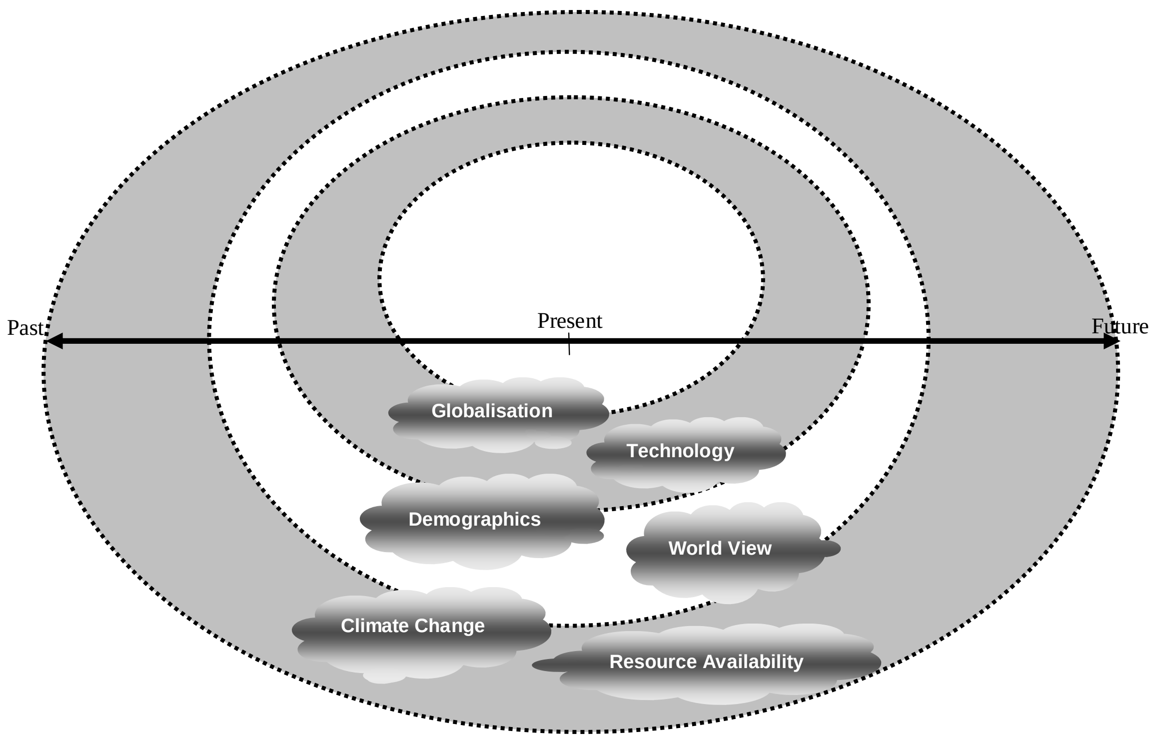


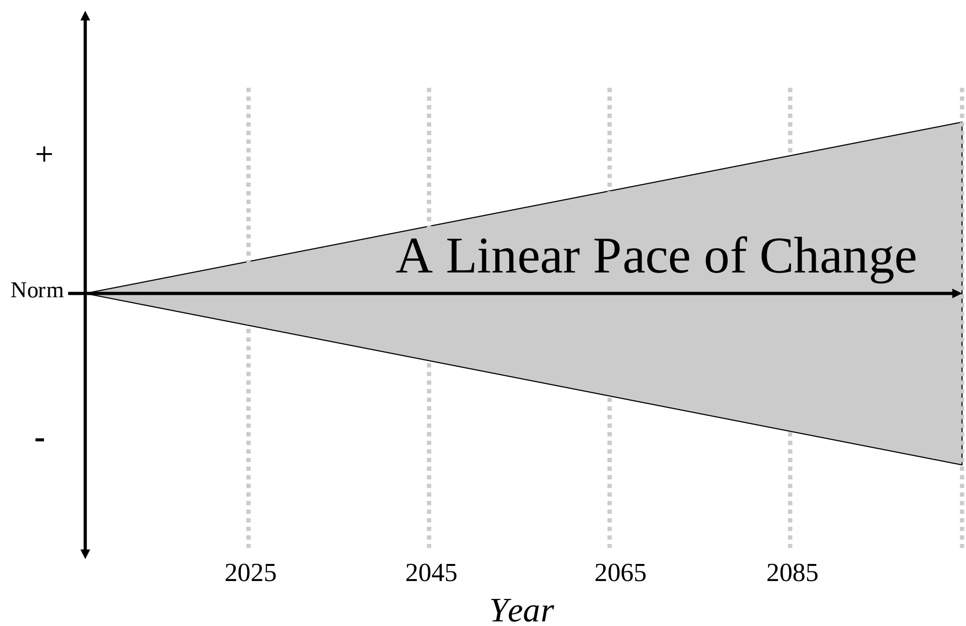
Figure 56 Driving forces the impact urban regions move at different rates, as shown by their location on the time rings

The remainder of this chapter will explore the nature of the associated threats for the first four of these forces, in each case adopting the unusual perspective of the urban region.

Technological Change

Technology refers to physical entities and management strategies. Technological change describes the process of invention, innovation and diffusion of practical ideas and products. [AZAR 99] Technological change in the last century covers everything from automobiles to televisions, birth control and computers. It has manifestly restructured all urban systems including lifestyle, culture, work, recreation, travel and communications.

Figure 57 illustrates the concept from a forecasting perspective. The first graph is a simple linear projection of uncertainty expanding over time, as would reflect the life experience of the individual observer. The second graph is the exponential change projected by actual trends, which effectively draws the future closer. A perceived 100-year horizon becomes a 25-year horizon. Effectively, long-term design becomes short-term design, and short-term design becomes a rear view mirror.



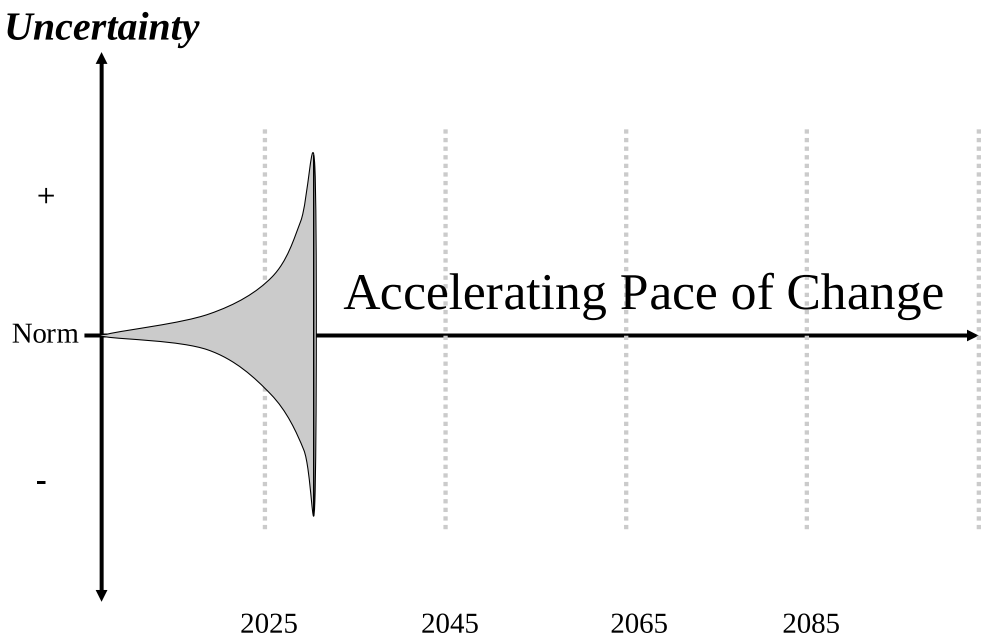


Figure 57 The cone of uncertainty shifts when the pace of change accelerates, effectively bringing the future closer to the present

The accelerating pace of technological change may represent a threat to urban regions. Kurzwiel, writing in the *Law of Accelerating Returns*, describes how exponential rate of change are difficult for people to grasp. Exponential change is non-intuitive because it does not reflect day to day experience our lives, or the way we understand history. People tend to perceive the future simply as an extension of the immediate past and present – superimposing past and present rates of change. You have to stand way back to see the curves. The amount of technological change that occurred in the 20th century equalled all the changes in the 200 preceding centuries. And the amount of change in the first 25 years of the 21st century will equal what occurred in the 20th century. [KURZWIEL 2003] A rapid pace of technological change in many fields, and the implied threats and opportunities for cities, reinforce once again the importance of S-curve literacy for urban planners and designers.

As described for energy patterns in Chapter 3, the high degree of uncertainty in the technology sector is further complicated by the potential for discontinuities in the trend lines. In very general terms, it would appear that some significant changes are now underway, and that much of the change is likely to culminate by 2035. Computers will have reached a density of information content equal to the human brain, and will likely be distributed throughout all elements in the constructed environment. The current period of innovation in technologies – including fuel cells, nanotechnology, and biotechnology – will also have converged into a wave that breaches and transforms. The transition from fossil fuels to the next energy era will be largely complete. [NACENOVIC 88] World population will have increased by 50% and will just be reaching a plateau, from which it is expected to shrink – beginning in 2050 - for the first time in many millennia. [WHO] Globalisation will have returned SE Asia and India to the centre of the world economy. [REVI 06] In other words, by 2035 it would appear that urban systems will be functioning in a world with very different issues and opportunities. Stewart Brand, amongst others, has described this coming together as a singularity – a point past which it is difficult to see, or plan. "What may happen decades from now – beyond the imagined event horizon – is treated as not only unknown but unknowable." [BRAND 99]

With this context, it can be argued that a 30-year pathway for urban systems is about the limit for strategic planning and design. As time scales extend past 30 years, the nature of the design challenge changes. Design strategies and risk management are replaced by pathways and intended end states that work well in multiple futures. This horizon is similar to the division the RAND team makes between risk and deep uncertainty.

Despite the rapid changes to technology the future for urban systems tends to be a lot more predictable than is recognized by most forecasters. Extremely slow rates of change (very gradual S-curves) define the basic infrastructure systems like transportation and energy grids. Nakicenovic has analysed these transitions for the US over the past 200 years, with some remarkable results. Figure 58 shows the substitution of transport infrastructures, moving from canals to railways to roads and airways at intervals of about 100 years. Because these systems tend to define land use and urban form, they provide an important brake (or memory) for the systems as a whole.

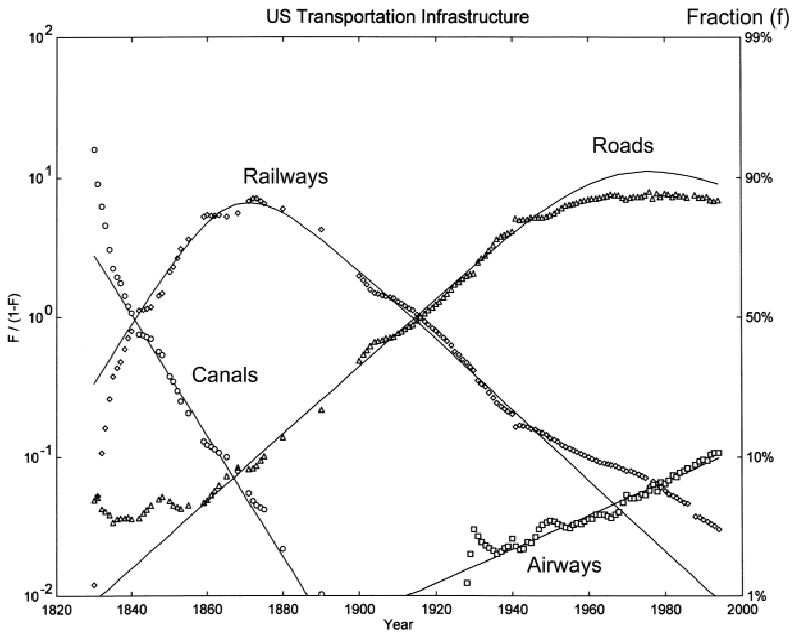
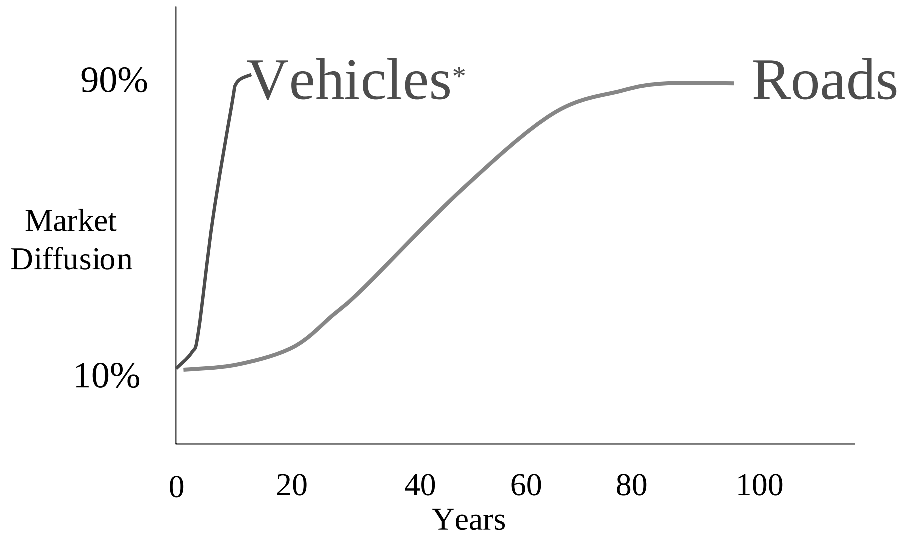


Figure 58 The substitution of transport infrastructures in the US appears to occur in 100 year cycles [NAKICENOVIC 88]

In marked contrast to these rates of transformation are the extremely rapid rates of substitution for motive power such as horse drawn street cars to electric, steam trains to diesel, horse cabs to automobiles with internal combustion engines. These transitions have a typical period of 12 years for moving a 10% to 90% market share. For these reasons urban system design is an awkward exercise. Some elements of the system, like vehicles, will transform multiple times in the time required for a single change in the basic infrastructure. These contrasting rates of change, and the unpredictability of the new technologies, emphasise the need for adaptability.



* Horse tram to electric, horse to auto, steam loco to diesel electric, reciprocating steam engine to turbine, horse cab to internal combustion engine

Figure 59 Innovations in basic infrastructure elements like roads penetrate the market at rates much slower than dependant elements like vehicles, hence the need for adaptability [road curve from NAKICENOVIC 88, vehicle curve from HOLLINSHEAD 06]

To continue the example of transportation system design, consider a roadway. Instead of High Occupancy Vehicle (HOV) lanes, what may be required are lanes that can easily adapt to a variety of alternative vehicles, speeds, and organising systems. Streets may need to be designed so they can easily accommodate new features like vehicle guide-ways. Large multi-purpose intersections may be required, to allow for reorganisation of slaved vehicle 'chains' and automatic rerouting. Current intersections may need multi-purpose spaces, so they can later accommodate intelligent controls and facilities for multi-modal operability. Fuelling stations may need to be expanded, since a variety of alternative fuels will emerge, some of which will be hazardous and some of which will require space to accommodate conversion technology (electrolysers, fluidized bed converters, and so on). Thus we can expect a greater need for the already limited space available for fuelling and hazardous materials storage within cities.

Higher traffic densities, and a greater diversity of modes and speeds imply more sophisticated traffic control systems, especially at on and off ramps and pedestrian-vehicle interfaces. The system may need to accommodate a different use of road space, although not necessarily more land area. On one hand extra space may be warranted for buffering to accommodate high speeds and multiple users and a greater variety of transportation modes, and to cope with noise levels, animal and human access, safety and the incorporation of emergency services. On the other hand much less space will be required due to the smaller vehicles, efficient flow management, and more compact community design. If vehicles become multi-purpose generators, then parking lots become power plants, and metering and power connections may be required everywhere vehicles are stored. If power generation efficiency depends upon the ability of systems to share waste heat with buildings, then the parking lots need to be carefully integrated into a compact community design for Combined Heat, Cooling and Power (CHP). Essentially, parking locations will need to be carefully integrated into the urban system, and multi-purpose in design, just like the new vehicles.

The impact of ICT on transit is particular difficult to forecast. If people have the option of high-speed private vehicle systems that integrate and disintegrate automatically, will they move away from public transportation? Or will much faster and more ubiquitous public transit systems offer robotized, light vehicles, and persuade more people to leave their private vehicles mostly at home or abandon car ownership? If ICT can relieve rush hour congestion through telecommuting and 'in-transit' work, the effect will be to greatly increase the capacity of existing rights-of-way. This raises the potential for avoiding major investments in new streets and intersections and possibly for 'de-streeting' - eliminating excess roads in favour of new parks and housing for example.

This one example illustrates the almost endless questions that arise in complex systems where the pace of change is uneven and accelerating.

Climate Change

Historical records indicate that human societies and cultures have been profoundly affected by climatic change. Even relatively recent history indicates that the transition periods in and out of ice ages presented monumental challenges that led to major cultural innovations such as the invention of irrigated agriculture and major religions. [IMBRIE 79] Even changes to wind patterns have meant changing civilizations. For example, when monsoons were weak, agriculture around the world was less productive and crop failure occurred in specific regions, with population collapse. Where they brought warmth and moisture, civilizations flourished, for example from 1,000 BC to 5,000 BC in the Near East and Central and South America. Lamb argues that such patterns are repeated throughout human history. [LAMB 88] In general, changes in climate have required mass migrations of people and adaptation to a new ecological niche - a pattern that may be difficult to repeat in today's densely populated world.

Over longer time scales climate change is thought to occur in both gradual and abrupt patterns. Most climate-change research has focused on gradual changes, such as the processes by which emissions of greenhouse gases lead to warming of the planet. This is known as the 'well behaved' paradigm that assumes stable relationships between variables that can be forecasted into the future. However, ice core samples … suggest that periods of gradual change in Earth's past were punctuated by episodes of abrupt change, including floods, droughts, and temperature changes of about 18°F in the span of decades. Whereas the 'well-behaved' school argues for a smooth and continuous warming trend, the 'phase change' school argues that there is a significant risk that a phase change into a sudden cooling could occur because of the warming.

An historical example for climatic flips comes from the latest research on core samples, in which abrupt changes in global climate correlate with warming episodes. It is thought that the release of freshwater in the North Atlantic from northern ice caps due to warming stopped the Atlantic Conveyor, a vast current of warm salty water from the Tropics and the Southern Ocean. It is the heat from the Atlantic Conveyor, picked up by westerly winds, which keeps Europe warm in winter. Remove the heat and Western Europe may encounter a new ice age in only a couple of decades. It could mean all Western European ports, from Bordeaux north, freezing every winter.

Climate change knowledge and understanding has changed rapidly over the past three decades. A critical mass of research has indicated that climate is indeed changing, although future scenarios are under debate, ranging from 'Gradual Warming' to 'Rapid Warming followed by Cooling'. Increased variability in climate is also predicted, and this alone can lead to surprises.

The Canadian Centre for Climate Modelling and Analysis' *General Circulation Model* suggests that in the latter half of the 21st century Greater Vancouver will likely experience an average annual increase in temperature of 1°C to 4°C, and an annual average precipitation increase of 10 to 20 percent. Winters will likely be warmer and wetter, and summers hotter and drier. The provincial experts expect sea level rises of up to 88 centimetres along parts of the BC coast, disappearance of many small glaciers in southern BC, drying of some interior rivers during the summer and early fall, changing salmon migration patterns and spawning success, and an expanded range of the mountain pine beetle – an important forestry pest. [BC Water, Land & Air Protection, 2002].

Every urban system may be vulnerable to such climate changes and to the more extreme weather events. Consider the impact of two consecutive dry winters on Greater Vancouver: no water in the reservoirs or behind the dams means 2 million people are without both water and power – with impacts on quality of life, safety, mobility, economic activity and so on. Climate change is probably a moving hazard to urban systems on all fronts.

Given the historical patterns and trends, and the variability in weather, urban regions may require a two-pronged approach to resiliency by design. The first approach, adaptation, integrates climate change planning with the expected global warming scenarios. Adaptation strategies for urban design might include increased investment in dykes, protection of wetlands, relocation of housing in low-lying areas, green infrastructure for flood proofing streets and parcels, and more robust storm sewer and transportation systems.

The second approach, resiliency, aims to mitigate the vulnerability to unexpected scenarios such as gradual or sudden cooling, and to extreme weather events. Contingency planning is required, along with increased self-reliance for critical water and energy needs at the parcel and neighbourhood scale.

It is also prudent for designers to consider the domino effects from climate change scenarios in other locations. Thus the region may need to accommodate climate-induced migration and homelessness, loss of remote ecological infrastructure, and the impacts of disease and strife on the food supply chains. Systems need to be designed both to prioritise scarce resources for essential services, and to expand services for unexpected demands.

Demographic Change

A long view of demographic change also reveals patterns and trends of significance to urban system design. In general, the literature suggests that population growth and dynamics have been strongly influenced by other driving forces. Changes in demographics cannot easily be defined in isolation, and are likely to always suffer from high uncertainty. Population growth cycles tend to correlate with resource availability, which in turn is influenced by climate and disease. [MARCHETTI 96] Migration can strongly influence population dynamics in a region. Migration of peoples is primarily influenced by changing regional economies, and also by a combination of related push/pull factors as shown in Figure 60. [WISNER 04] For example, the population of North America grew 13.5 times between 1800 and 1900 (from 6 to 81 million people) compared to Asia where population did not double in the same time period (from 602 to 937 million people). This difference is a result of 50 million immigrants arriving in North America. For all these reasons population predictions have frequently been proven incorrect.

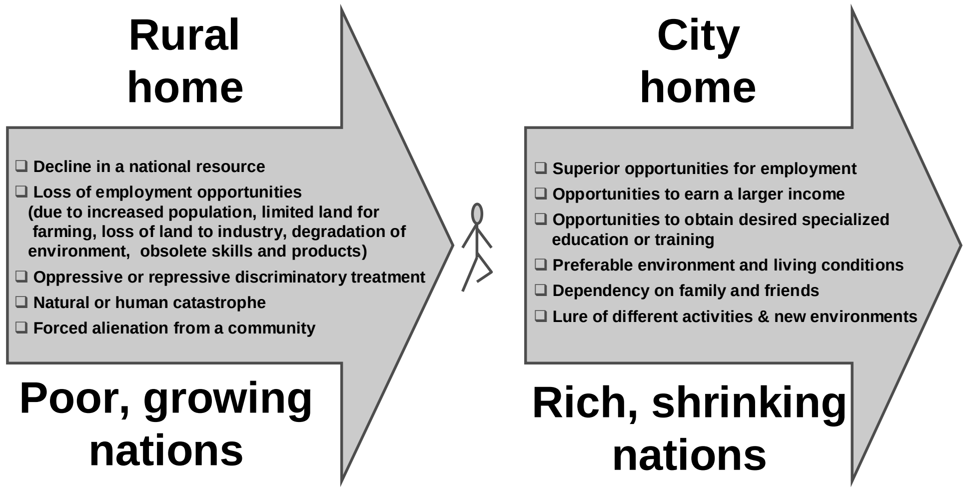


Figure 60 Both urbanisation and migration are phenomena driven by multiple push/pull factors [adapted from Bouge in WISNER 04]

That said, some mega-trends are evident that appear to shape demographics for cities world-wide. Global population growth, combined with urbanization, will help to make this the urban century. All countries clearly show increasing urbanization trends. [MCNEIL 2000] Population is projected to grow by two billion people by 2030 and an additional one billion by 2050. [WHO] Much of the growth will be the developing world where many countries will have predominantly young people.

According to David Foot, author of *Boom, Bust and Echo*, "Demographics explain about two-thirds of everything." [FOOT 98] Foot uses demographics to project many aspects of the future, including demand for products and services, school enrolment, drug use, types of crime, investment patterns, immigration and emigration between parts of the world, housing needs, and so on. He argues that population projections are most difficult for towns and cities, since they are subject to immigration flows at the regional, national and international level, all of which are uncertain. However demographics can help with such projections in surprising ways. Most immigration into Canada, for example, ends up in just three urban regions. The source countries are located in regions of the world with large numbers of young people, and thus the cultural background of immigrants will vary with the aging of world regions. In the 1950s the source of immigrants was Britain, Scandinavia and Germany; in the 1950s and 60s immigrants came from Greece, Spain, Italy and Portugal; in the 70s, 80s and 90s immigrants came from Asia; the next wave of immigration will be from Latin America and after that Africa. Emigration, on the other hand, flows in reverse, as aging Italians, for example, return to their mother country in retirement. These people flows and cultural attitudes have substantial impact on long-term urban system design.

Variable aging by country and urban region may also lead to a differences in time concepts at the international scale. Assuming that time preference is a factor that varies with age, the future of demographics may create a polarized world culture with developed countries sharing a low time preference, and developing countries a high time preference. Under such conditions, will sustainability require massive amounts of negotiation and wealth transfer from aging regions to younger regions?

Despite growth and urbanisation, the century is likely to experience declining populations overall, especially in some regions. Demographers at the United Nations now predict that 9 billion people in 2050 will be a peak, after which numbers decline to less than 6 billion people at the end of the 21st century. Absolute population declines are already taking place in many countries, including Japan, Italy and Russia, which expect to have 14%, 25% and 30% fewer people by 2050, respectively. Canada's fertility rate has also fallen below replacement, and populations of both Canada and Greater Vancouver would currently be declining without immigration.

Regional depopulation will change age structures. According to the United Nations, one out of every ten persons on the planet is now 60 years or older; by 2050, one out of five will be 60 years or older; and by 2150, one out of three persons will be 60 years or older. This aging leads to labour shortages and high dependency ratios. Regional depopulation also induces changed import demands and competition for immigrants. Thus migration is a major trend both within developing and urbanizing countries, and between the north and the south. Regions like Greater Vancouver will be dependant upon prolonged migration to sustain age-specific programs like pensions, health care, social services. (BAXTER 2000). Figure 61 shows two curves for population in the region over the century, one with and one without migration. The huge gap reflects not only the dependency, but also the inherent uncertainty. Where will the population come from, when and why? What kinds of housing and neighbourhoods will be needed, and how will existing structures adapt to accommodate so many newcomers?

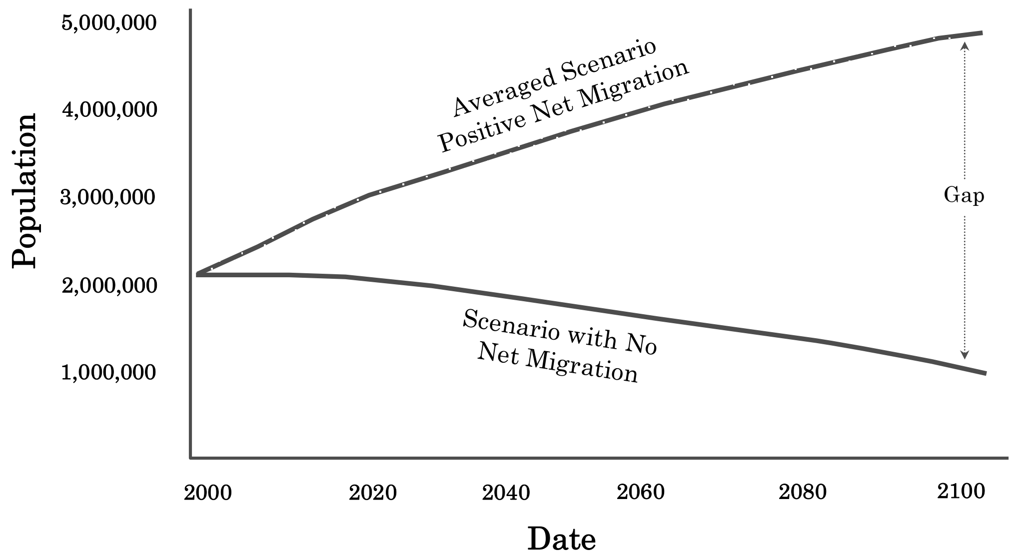


Figure 61 Very different futures can be projected for Greater Vancouver, depending upon the rate of migration [*CitiesPLUS* 03]

The Greater Vancouver situation also emphasises the problems with generalising about long-term demographic forces and strategic responses. While the region is projected to continue growing at high rates, it is partly at the expense of the rural hinterland. Only four regions in Canada are growing and they already contain more than half the national population. Elsewhere, with few exceptions, populations of town and country are in decline. Urban regions in Canada, like many elsewhere, must consider the possibility of very different demographic futures. Since the demographics drive so much of the demand for urban services, design strategies must become extremely adaptable. [FOOT 98]

Globalization

Cities are now in the front lines of a radical adjustment that is integrating many cultures and socio-economic classes into a global trading and production system. According to Herman Daly, globalization refers to "the global economic integration of many formerly national economies into one global economy, mainly by free trade and free capital mobility, but also by easy or uncontrolled migration. It is the effective erasure of national boundaries for economic purposes." [DALY 99] It is also about the integration of nations and cultures to one dominant society or culture. On the highest level, it is about replacing the cold war system with acculturation to liberalism, rationalism and pluralism. On a more political level it is an unprecedented shift towards world-scale corporate networks; progressively centralised power; corporate decentralisation and the merging of national, international and corporate fragments into a global system. [FRIEDMAN 92]

Civilization has witnessed an evolving series of world economies, centred on specific technological advancements and territorial control. [KENNEDY 89] [MCNEIL 01] [SANDERSON 95] In this context, globalization is as old as technological innovation, trade, and military conquest, which are the factors that drive it. Since the Middle Ages, the history of the West is a history of successive globalizations by the Venetians, the Spanish Netherlands, the Genoese, the Dutch, the English and finally, the Americans. This long history makes possible identification of long patterns and trends.

In rather simple terms, each era of globalization creates a new 'world economy' with a 'world city' at its centre. [WALLERSTEIN 98] [FRANK 98] The world economy comprises a hierarchy of urban regions (metropoles and their hinterlands), tied to these world city through trade, conquest, and treaties and trade agreements. As these hinterland cities grow and develop, they begin to generate savings out of the flow of income and revenue, and become quasi-independent sources of wealth creation. The world city begins to lose its grip on the pool of savings in the system as well as on the manufacture of advanced products that generates revenues. Eventually the long-term cycle repeats.

Today, the economic *core* is less compact and the economy has become truly global, and more complex. Leading edge innovation is taking place in many locations because the *middle zone* is also larger, especially with the spread of high-quality secondary education and virtual businesses. The centre of wealth generation is currently undertaking a slow transition. Figure 62 shows national GDP as a percentage of the world total over the past 500 years. "India and China made up over 50 percent of global output over much of this period from the 6th to the late 16th century. The effect of western colonial expansion is apparent as their relative share in global output drops dramatically over the 18th and 19th century, recovering only in the middle of the 20th century. At the same time the notional centre of gravity of the world-system shifted from its locus in Western Europe, to USA and Japan." [REVI 05] During the next 30 to 40 years the entire system is expected to rebalance. With the rapid economic expansion in East Asia, and South Asia, comes a shift of global hegemony from the Atlantic Ocean to the Pacific-Indian Ocean basins. [FRANK 98].

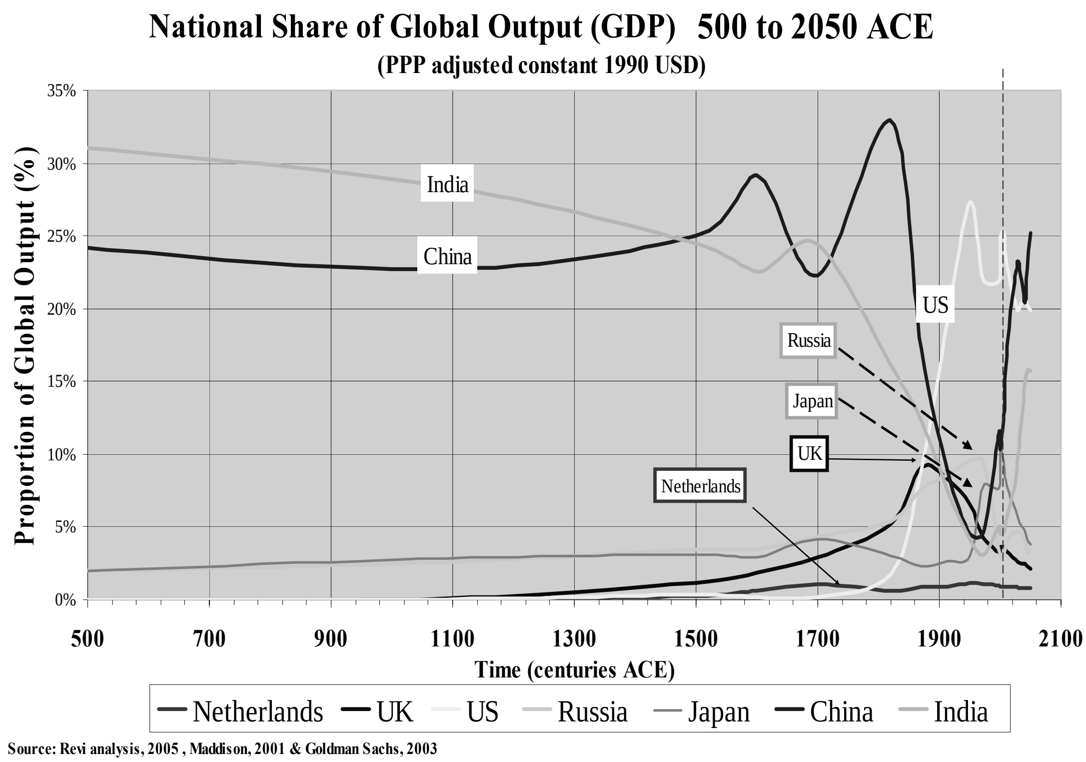


Figure 62 Time extensions of economic output reveal tectonic shifts in global economic hegemony in the early 21st century [REVI 06]

The consequences for globalization on urban regions are likely to be significant, affecting their trade, security, migration, culture and environment. For some it will mean moving from the centre to the periphery of the world system, or vice versa, and the strategic choices around energy and resource systems must accommodate new roles. For a gateway city like Greater Vancouver, located on the Pacific Rim, with strong ethnic ties to Asia, the change may represent an opportunity to step up the hierarchy.

The core cities of tomorrow will be found among those cities that adjust quickly to the changing geopolitics of the world system, and to the changing technologies that drive the 'new economies'. Regions must define their place in the emerging global networks for ICT, biotechnology and nanotechnology, new materials, and alternative energy technologies. Industrial and municipal 'ecologies' - or 'economies of scope' – may once again become more important than economies of scale. And in an age when businesses and professional workers are extremely mobile, economic success may increasingly depend upon the 'urban experience' and the quality of urban design – commuting distances, air quality, human security, diverse cultural landscapes and a stable and beautiful built environment. In Vancouver the professional working class may now value short commuting distances as more significant that salary levels. Such factors may define the middle zone cities of tomorrow.

6.3 The Essentials

Historically, security policy probably originated with defensive design features adopted by the city states of antiquity. More recently security policy seems to have traveled a full circle, through national security, human security, domestic security and – perhaps - now back to urban security. In general, it is reasonable to assume that vulnerabilities to all kinds of risks will increase in parallel with urbanization, and that the future will be punctuated by a variety of city-based disasters and societal collapse. This may be a defining characteristic of the century ahead.

Globalisation has greatly increased interdependencies between urban regions, with a corresponding need for greater foresight and contingency planning. The security of an urban region may now be inextricably linked to the sustainability of key trading partners. Urban regions may now require a diversity of global partnerships and an expanded scope for emergency planning and reserve funding. Even without the dependencies of trade, the potential collapse of mega cities in developing countries poses a major threat to urban regions elsewhere.

Critical infrastructure systems are not well understood, but the scope of what is defined as critical, and the number of players involved, has been expanding. Complexity is also increasing, and may become ever more challenging if urban regions adopt more ecological design principles. Emergency planning that focuses on the long-term resiliency of critical infrastructure has recently received attention. However despite terms like 'disaster resilient communities', the efforts to date are limited to reactive response and recovery.

Extended time scales make possible a great number of design solutions which are rarely or never considered by conventional teams of emergency planners. More specifically, it becomes possible to reduce vulnerability of the long-lasting elements of the urban system – buildings, roads and institutional structures. It may also become possible to develop a culture of preparedness, to map the risks on the landscape of the region. Urban regions may need 'learning systems' – like adaptive management - that assume surprise and failure. Such systems are flexible, lack apparent structure, have no fixed centre, and incorporate overlapping networks and feedback loops for active learning and flexibility. In the future, learning capacity and flexible design within urban regions may become 'sources of novelty' that help to transform systems so that they adapt to surprise.

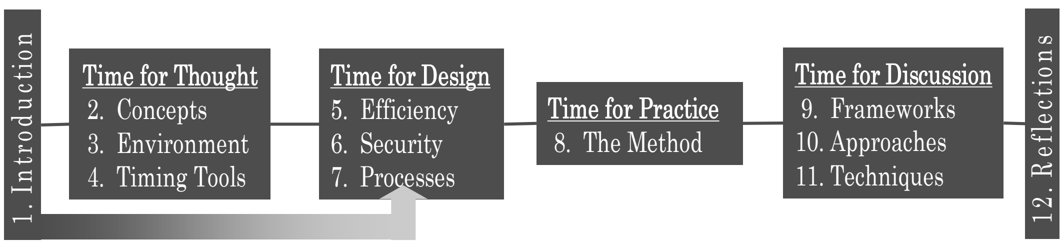
Incorporating uncertainty into life cycle scenarios can be extremely challenging, especially when coping with the deep uncertainty introduced by longer-term horizons. The longevity of system design may correlate only with simple, common-sense design principles: for example fewer interdependencies reduces vulnerability; generic and flexible the features increase adaptability; survivor traits from history may help systems survive in the future. It may also be worthwhile to consider fundamental principles of resilient design, drawn from ecological theory and systems analysis, including such design concepts as modularity , redundancy, and self-organisation.

Driving forces that may transform urban regions over the next century include natural disasters, climate change, demographics, world views, globalisation, technological change and resource availability. A cursory examination of these forces suggests that over the long-term urban regions will be facing an increasing diversity and frequency of shocks, and that urban sustainability is inseparable from urban resiliency. Most forces may lie largely outside the sphere of influence of local decision-makers. However with sufficient knowledge of historical patterns, trends, and uncertainties it may be possible to design urban systems that are inherently less vulnerable. The greater these threats become, the more arguments exist for urban regions to become involved in on-going intelligence gathering, scenario development and proactive security planning.

As Dennis Mileti argues, now may be the time to redefine sustainability as a combination of traditional definitions merged with a long-term perspective that includes local resiliency and local responsibility. [MILETI 99] The question that remains is how best to integrate such a new perspective into the design process.

7 How might New Time Concepts affect the Process of Design?

Long-term urban system design is unlike other types of planning and design work such as personal, corporate, or institutional. Urban systems require a process of design for and with a community. The community has both a physical component that is never completely built and that is made up of discrete, unique and integral parts, and a human dimension that is constantly changing and that is always subject to a multiplicity of objectives [HODGE 86]. This chapter will take a brief look at the time dimensions of processes for community planning and design. In particular it is necessary to explore the history of the future in design. How have designers portrayed the future? Do time concepts help to engage a broad community of interests? Has the process of design facilitated the use of timing tools?



7.1 Can Design Frameworks Help to Extend Time Horizons?

7.1.1 Urban Design Frameworks

Most planning or design exercises begin with a framework, explicit or implicit. The term framework is used here to refer to the mental model that guides the design process, helping to organize tasks and outputs into a logical sequence. The framework may be non-verbal and intuitive: "begin by *meditating on the problem, the wait for the 'big' idea, and work out the details".* At the other extreme, the framework may be imposed through an elaborate institutionalised structure, with mandates dictated from above, specific departments responsible for strategic policy, others handling the rules and regulations, applications and evaluations. Regardless, a framework is a kind of hierarchical index which is used to guide urban system design process from start to finish, and to organise the results. It is the framework that keeps the work coherent for the individuals involved, providing a context for all tasks and decision-making, from moment to moment and from year-to-year.

Much of the published literature on planning frameworks focuses on ‘corporate’ strategic planning, where a framework functions as a way to create a “shared mental model of the company, their markets, and their competitors”. [SENGE 90]. Urban planning and design is different from corporate planning due to increased complexity, larger number of participants, longer time horizons, and the preponderance of site-specific factors. For these reasons an urban planning and design framework is often addressed in two parts: the technical framework which guides the physical design, and the normative framework which guides the participatory process and the decision-making structures.

In the rapid growth of urban centres that followed the Second World War the process of urban design changed from what was largely a technical process, modelled on technical frameworks and traditional architectural terms, to a model that was more normative, systematic and rational-comprehensive, accommodating a more mixed economy and more pluralistic society. [FRIEDMAN 06]

Over this time period, interest in planning methodology and the role of frameworks and ‘framing’ has focused on three questions: how to use frameworks to enhance collaborative decision-making and participatory planning and design [BRYSON 92]; how to use frameworks to handle complexity [GHARA 06]; and how to use frameworks to cope with uncertainty or to increase learning and adaptive capacity [GUNDERSON 02]. All three issues are especially relevant to the long-term planning methods in this thesis. Frameworks represent one of the possible ‘timing tools’ that may need to be improved or revised in order for design teams to succeed in creating sustainable systems.

From this perspective, part of this research is an enquiry into how frameworks function and evolve in the context of extended time scales. Can frameworks facilitate communications amongst an integrated, collaborative urban design team? Can frameworks help teams cope with the added complexity of long-term horizons and sustainability? Can frameworks manage the process of adaptation and learning over time?

Framework structures

There are many historical approaches to structuring the planning and design process at the urban scale and the approaches have changed with remarkable high frequency. Hall argues that the constant redefinition of what constitutes urban planning has contributed to confusion within the profession, and amongst the design field generally. [Hall 89] The first systematic attempt to design a framework for community planning was the rational-comprehensive approach in the early 1950s (e.g. Myerson, Banfield) which proposed a three-step process: 1) consider all possible courses of action, 2) identify and evaluate the consequences of each alternative, and 3) select the alternative that is most likely to achieve the community's highest priority objectives. [HODGE 86]

Ira Robinson has adapted this framework to include more recent thinking, and the result is a five step process: 1. Identify the problem(s), need(s), opportunities, goals and translate broad goals into measurable operational criteria; 2. Design alternative solutions or courses of action (plans, polices, programs, projects) to solve the problems or fulfil the needs, opportunities an goals, and predict the consequences and effectiveness of each alternative; 3. Compare and evaluate the alternatives with each other and with business-as-usual, and help the decision-maker choose the alternative with the most preferable probable consequences; 4. Develop a plan of action for implementing the selected alternative, including budgets, schedules, regulatory measures, designs etc.; and 5. Maintain the plan on a current and up-to-date basis, based on feedback and review of information to adjust steps 1 through 4 above. [ROBINSON 82] A flow chart for the idealised compressive-rational planning process is shown in Figure 63.

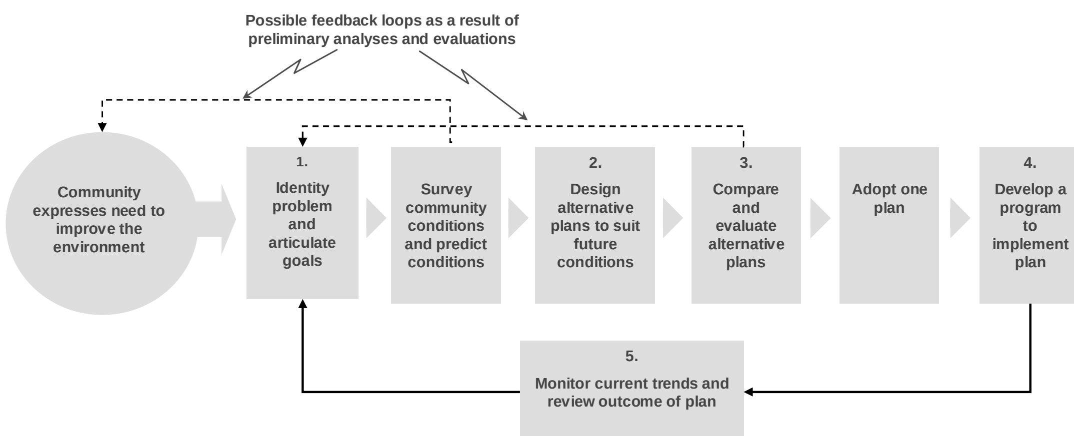
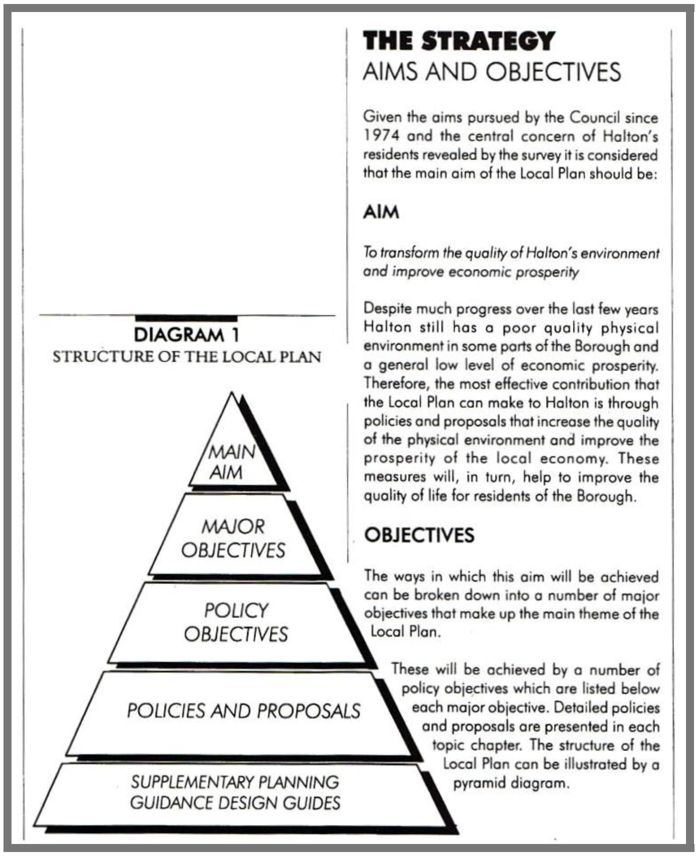


Figure 63 A general model of the community planning process, with a five-step approach to comprehensive rational planning [From HODGE 98, redrawn by author]

In their text on *The Design Dimension of Planning – Theory, content and best practice for design policies*, John Punter and Matthew Carmona argue that all design policies should be conceived as a hierarch, working from district-wide to local scales, and from plan strategy and statutory policy to supplementary design guidance. "Organisation of policies in such a hierarchical frameworks helps to create a logical relationship between them, and aids the comprehension and comprehensiveness of the plan." [PUNTER 97]. As a good example they cite the Halton (UK) Local Plan, adopted in 1996, an extract of which has been reproduced in Figure 64, showing a pyramid diagram. In their conclusions Punter and Carmona emphasise the value of frameworks that include evaluation criteria, that include reasoned justifications, that are comprehensible to skilled designers and that are well indexed and cross-referenced for integration and coordination.


THE STRATEGY

AIMS AND OBJECTIVES

Given the aims pursued by the Council since 1974 and the central concern of Halton's residents revealed by the survey it is considered that the main aim of the Local Plan should be:

AIM

To transform the quality of Halton's environment and improve economic prosperity

Despite much progress over the last few years Halton still has a poor quality physical environment in some parts of the Borough and a general low level of economic prosperity. Therefore, the most effective contribution that the Local Plan can make to Halton is through policies and proposals that increase the quality of the physical environment and improve the prosperity of the local economy. These measures will, in turn, help to improve the quality of life for residents of the Borough.

OBJECTIVES

The ways in which this aim will be achieved can be broken down into a number of major objectives that make up the main theme of the Local Plan.

These will be achieved by a number of policy objectives which are listed below each major objective. Detailed policies and proposals are presented in each topic chapter. The structure of the Local Plan can be illustrated by a pyramid diagram.

DIAGRAM 1

STRUCTURE OF THE LOCAL PLAN

Figure 64 An example planning framework from Halton UK (1996) that uses a rational framework of five layers to make the plan and process more comprehensible and integrated [As cited in PUNTER 97]

In the real world little discussion may occur regarding the choice of a design framework. Urban system design at community or regional scale is often ad hoc, driven by product deliverables. For this reason it is easy to skip levels, and also to avoid aligning decisions at one level with decisions at the next. In many urban regions the process of urban design is not explicit or structured, so frameworks are invisible. Many growing cities in developing countries are lacking even the institutional structure for urban system planning and design. The city of Tijuana, a participant in the 100-year planning exercises described later in this thesis, has a population of 4 Million (twice that of San Diego) and yet had no planning department until 1999, and is still almost entirely dependent upon developers for system design.

Even the most robust and carefully planned approaches can appear to be somewhat limited. A good example of a well-tested framework is the Local Agenda 21 program developed by the International Council for Local Environmental Initiatives (ICLEI). In the lead up to the 1992 Rio Earth Summit, ICLEI developed and proposed the concept of LA21. It was endorsed at the Summit as Chapter 29 of Agenda 21, the global action plan for sustainable development. This initiative has led to the single largest network of local governments moving toward a common goal. More than 6,400 local governments in 113 countries worldwide responded to the goals of Agenda 21 by developing and implementing "local" Agendas 21. [ICLEI, 2001] The LA21 plans initially employed a very simple framework, but more recently this has evolved into the five milestones, as shown in Figure 65. Note that no accommodation is made for forecasting, scenario analysis, modeling, sensitivity analysis and the other exploratory research activity that helps to inform the choice of overall strategies, prior to adopting actions. More frequently it is the initial scoping and final evaluation stages of design are completely overlooked in design frameworks.

LA21 Campaign Milestones

1. Establish a multi-sector stakeholder group to oversee the LA21 process, consisting of representatives from all sectors of the community, that will be formally involved in the development and implementation of all actions aiming at the achievement of the LA21 Campaign milestones.
2. With the active participation of the LA21 stakeholder group, complete a sustainability audit considering social, economic, and environmental conditions and trends in the community.
3. Complete a sustainable community vision for the future, based on community review of the audit and assessment of priorities.
4. Implement an LA21 action plan, identifying clear goals, priorities, measurable targets, roles and responsibilities, funding sources, and work activities.
5. Establish community-based monitoring and annual evaluation and community progress reporting on performance in achieving the LA21 action plan, using locally appropriate indicators

Figure 65 The five-step planning framework used for Local Agenda 21 programs promoted by the International Council for Local Environmental Initiatives appears to lack any strategic exploration stage [www.iclei.org/]

Gaps and confusions exist in most planning and design exercises, and point to the value of a rigorous and transparent framework. Hari Srinivas, in his article on *Urban Environmental Management: A Partnership Continuum*, makes a strong case for an Urban Environmental Framework to assist groups in structuring and rationalising the design process. “While the contents of a framework provide a broad vision, its applicability lies in establishing policies, programmes, and projects that operationalise the objectives in the long term and set up mechanisms to monitor and evaluate at every stage." [SRINIVAS 99] His proposed *Urban Environmental Partnership* framework positions actors on two axes: ranging from NGOs to Government and from local to international. Unfortunately this framework is not suitable for design exercises that may need to include a broader cross-section of organisations (e.g. private firms and institutes) and greater diversity in expertise and commitment.

Currently the design process is not well framed at the regional scale, although some notable exceptions exist. Typically a combination of plans emerge from different departments, levels of government and sectors – private, public and cooperative. The plans have no formal alignment process, and do not share time scales, goals, targets or tool sets. The result can be oddly mismatched or even contradictory plans. An example from Greater Vancouver is the lack of alignment between plans for growth management and land use, in the ground infrastructure, and transportation. Over 50% of the new commercial development occurs in locations that are not designated for development in the regional land use plan. Office parks locate where land is inexpensive – rather than close to homes, transit, restaurants and daycare – and yet the infrastructure services like water, roads, power and gas are automatically provided as a service to the property owners.

Often infrastructure development will the drive land use planning, since the infrastructure engineers tend to work in a more staged fashion, with longer-term horizons. [NRC INFRAGUIDE] The lack of alignment amongst key plans reflects, in part, the lack of control by local governments over land use and private property rights. Under such conditions, the potential for long-term design is limited.

7.2 What futuristic processes apply to urban design?

Peter Hall, writing in *Cities of Tomorrow, An Intellectual History of Urban Planning and Design in the Twentieth Century*, has argued that the history of urban planning itself is characterised by frequent cycles that have tended to confuse any effort to evaluate the potential role of urban planners and designers. [Hall 02] At its origins, the planners and theorists were often utopian in the sense intended by Thomas More, who first used the term in his 16th century novel Utopia. Although the term utopian has now acquired a sense of something impossible or absurdly idealistic, it is more accurately about using imagination. Lyman Sargent set the standard definitions: utopia is the genre, eutopia is a good place, and dsytopia as a place worse than the present. [LYMAN 76] [SCHAER 06] James Dator proposes that 'eutopia' be a term that refers both to good places and feasible futures. [DATOR 88]

The futuristic element of utopian planning has changed over the past century. Initially it would seem that utopian urban design was introduced as a very pragmatic and immediate solution to social problems. Although presumably the solutions were intended to last indefinitely, it was not necessarily a long-term process. Time extensions are more relevant to recent utopian planning, where the scale of urbanisation and the complexity of problems require a transformative approach and a process for managing the change.

The world today has no shortage of transformational proposals for urban utopias and eutopias. In many ways people are ever more attached to the culture of cities and the amenities that cities can offer, as Hall points out in his introduction to Cities of Tomorrow. However the planning process itself may have lost the imaginative and fearless element necessary for utopian planning. In part this reflects the extended present, and the postmodernist perspective, as discussed in Chapter 2. In part this may also be attributed to the complexity of identity for communities that now consist of highly mixed economies, a pluralistic political system, and an educated and active population. How then is utopian planning and design to survive? What process can achieve consensus on visions for sustainable development within an entire urban region, and translate the dreams into reality?

White and Atkinson argue that "the design of a utopian city was never a more urgent and practical task for the urban planner." [WHITE 94] [ATKINSON 91] What has changed, they say, is the need to imagine new designs for the physical aspects of the city – the ecological city. The utopian urban planning movements of the early 20th century were primarily concerned with social and economic goals. Today the urban footprint and environmental performance factors have become another priority issue, deeply interwoven with the quality of life issues at every scale. New paradigms like the 'healthy cities and communities' and sustainable development may be an attempt to reconcile traditional utopian planning with the complex modern world and its new players and priorities.

Modern-day utopian urban design has both a technical and a normative side. The technical process involves a much more 'Integrated Design Process' (IDP) to enable a systems approach. The normative process requires much more 'Collaborative Decision-making' (CD) to facilitate a coordinated approach to implementation.

7.2.1 The Integrated Design Process (IDP)

Unlike the traditional planning and design process, which begins with a small team lead by an architect and later adds experts when needed, IDP engages a wide range of specialists, local stakeholders, and partners at very early stages. The object is to use their expertise to influence seminal design decisions before opportunities are constrained, and to find the synergies and out-of-the-box solutions that help to make sustainable development practical and affordable.

IDP is an approach to urban design emerged as a by-product of green building programs. It is arguably the single most criteria for success in the green building design process. For example the Canadian Building Incentives Program (CBIP) was initially based upon the assumption that advanced capital equipment would be the most important factor in performance; however after the first round of projects it became clear that design process was more important, and that IDP should become an essential element of all future projects.[28] Ideally an IDP team will include individuals with knowledge and responsibility for operations, maintenance, refurbishment, and community relations. The entire design team may participate in an inspirational target-setting workshop at the beginning of a project. Targets – or constraints – adopted by the team may continue to inform decisions on the project throughout all stages of design and even after occupancy.

IDP can benefit from a facilitator, to improve communications within the team, and to help experts and stakeholders negotiate the inevitable trade-offs. IDP typically involves some degree of energy modelling and value analysis in parallel with preliminary concept design work. 'Whole-system engineering' may also be used to provide broad thinking about alternate technical options at the concept stage. Consequently more time and budget is needed up front in the design process – and project managers must be convinced to reallocate time and budget.

7.2.2 Collaborative Decision-Making

Collaboration is a process for co-design and shared decision-making. Figure 66 illustrates key differences in information flow and authority, contrasting a collaborative approach with the more traditional regulatory, advisory and consultative processes. Collaboration is essentially an ad hoc arrangement for cooperative planning, even if the process for communications is formalised and sophisticated. Collaboration is a method by which disparate groups can join together for a common purpose, without necessarily altering their mandate, relinquishing their authority, or sharing their budget. In other words, the power structure is retained. What is different is the information flow and the potential for joint action.

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[28] CanMet Energy Technology Centre's program on Sustainable Buildings and Communities: http://www.sbc.nrcan.gc.ca/buildings/idp_e.asp accessed June 06

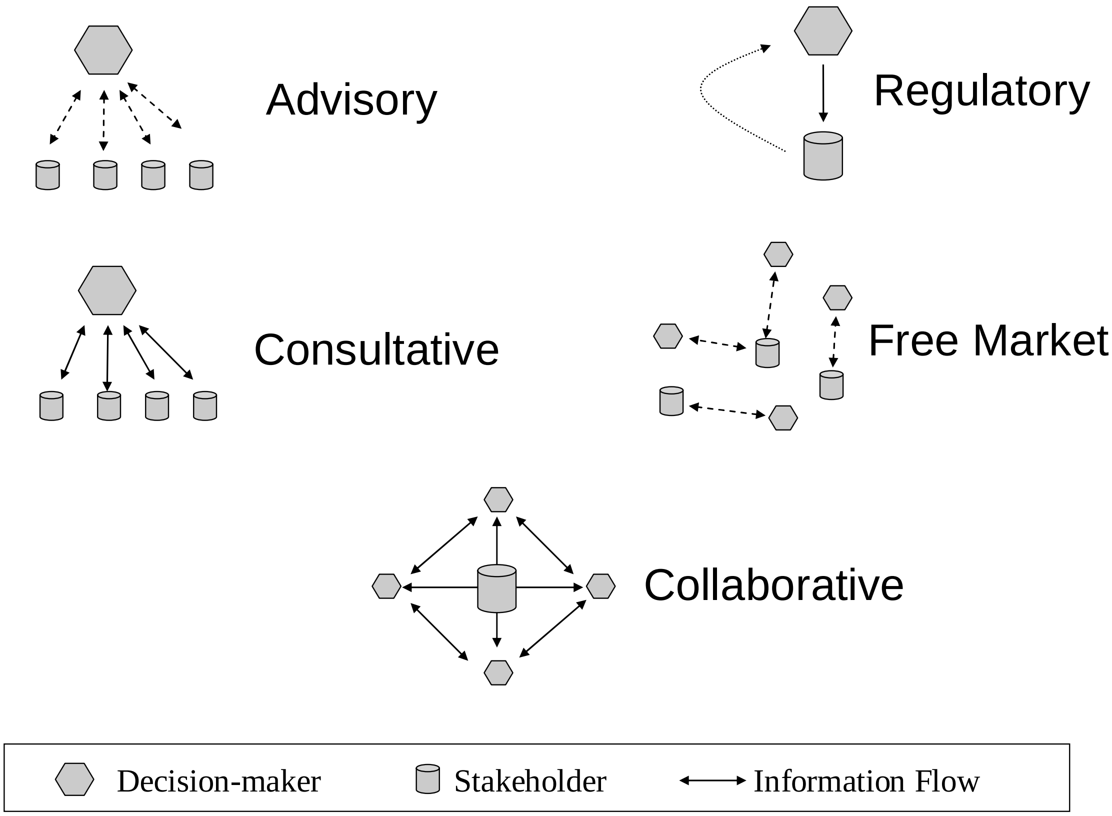


Figure 66 A collaborative model replaces hierarchical structures with consensus decision-making – control disappears but the potential for exchange and cooperation increases

The term collaborative planning was adopted by a number of sociologists in the 1980s, following book Bryson and Crosby's seminal book on *Leadership for the Common Good*. Bryson and Crosby argue that we live in a 'shared power' world in which organisations and institutions must share objectives, activities, resources, power or authority in order to achieve collective gains or to minimise loses. "A key task in this shared power world is to include existing hierarchical organisations in the networks that we create to responds to unwieldy problems and issues." [BRYSON 92] They describe how to use informal networks to create a flexible governance structure with 'no one in charge'.

Two aspects of Bryson and Crosby's 'shared power' appear to have special relevance for long-term urban system design. First, they argue that a hybrid form of decision-making is required that effectively merges the technically-rational or deductive model with the politically-rational or inductive model. Figure 67 illustrates these two very different processes. The technical model assumes that consensus exists on what the problems are and how they should be defined, and looks for the logical solution – this is a traditional rational design model. The political approach assumes that there are conflicts or issues to resolve, and the solution is mostly about creating a consensus among the groups concerned – a normative model that is rational only from the perspective of politicians and change agents.

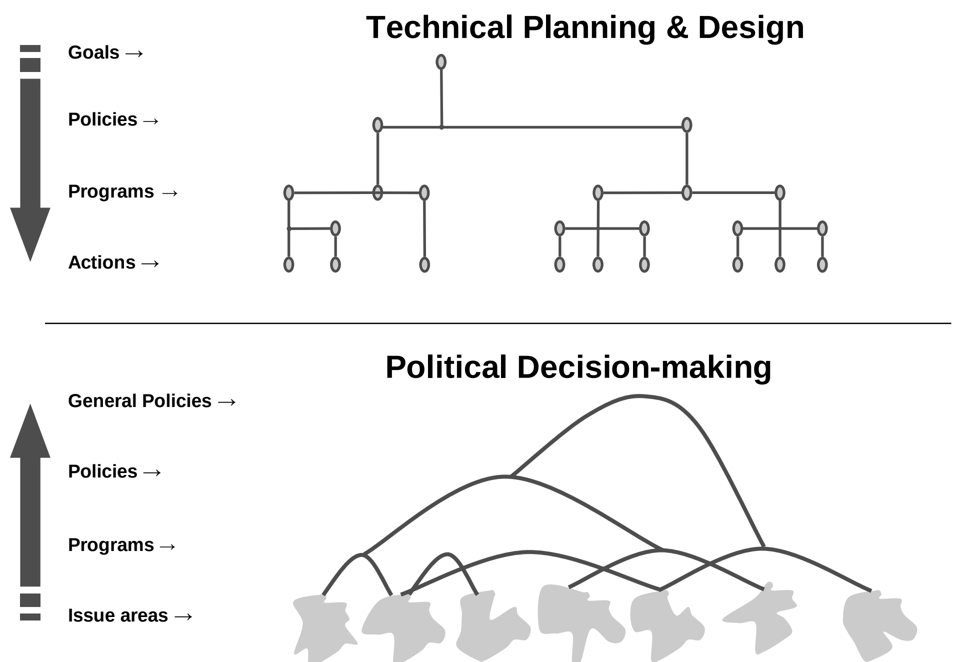


Figure 67 Technical Planning and Design - the rational approach - contrasts sharply with the more common approach of political decision-making [from BRYSON 92, redrawn and expanded by author]

Bryson and Crosby point out that the challenge is to use both models appropriately, and often in sequence. For example the political model helps to determine the issues and the values, while the technical model informs the groups involved, and develops technically workable goals, policies, programs and designs. Such arguments can be extended to address the special difficulties of long-term design, where technical programs and designs are likely to encounter an even greater number of regulatory and financial obstacles. The role of the political process can be to help removal of institutional barriers that so commonly frustrate the implementation of rational design solutions. With a suitable structure for design and decision-making teams, the political process can support rational design, and vice versa, creating a virtuous circle as shown in Figure 68.

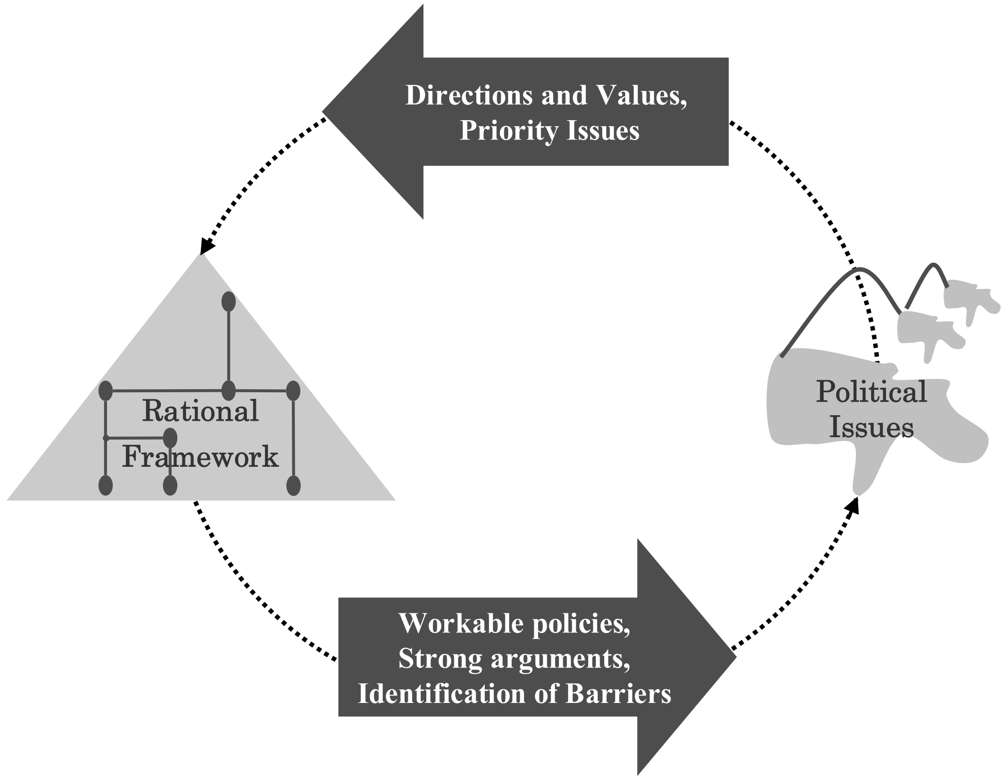


Figure 68 A virtuous circle: the rational framework provides workable models, strong arguments and clarity for the political decision-makers; the political framework is high-priority issues for analysis and assists with removing institutional barriers.

Bryson and Crosby suggest that shared-power arrangements are a key strategy in responding to complexity and risk, since they serve both to manage the complexity of solutions to share responsibility for outcomes. Shared-power relationships may not be possible between political adversaries, and may not be necessary between closely allied groups. However for the mid-range of the scale, it becomes a model for bringing together organisations and groups that lack any mechanism for regularly meeting and communicating, and would otherwise be unlikely to share concerns and plans within a common domain.

In the literature on leadership in organizations and countries, shared-power arrangements are sometimes called 'regimes' – "sets of implicit or explicit principles, norms, rules and decision-making procedures around which actors' expectations converge in a given area." [KRASNER 83] The most useful regimes are regimes of mutual gain, focused on desires for a better world. What may now be required is the formation of effective and stable urban regimes that can work to manage the complexity of long-term system design. Brugmann describes the case study of Curitiba, Brazil, among others, where successes in sustainable urban design can be attributed to the existence of urban regimes operating in a shared-power arrangement. [BRUGMANN 02]

Collaboratives begin by agreeing to some of the principles and norms that Krasner describes, and in particular on a common vision of the desired long-term outcomes. Ideally the analysis and research work is shared and directed, and thus can be jointly owned by the whole collaborative. Wherever agreement on strategies is reached within the collaborative, then each participating group can use its unique mandate and resource base - in a more or less coordinated fashion - to contribute to the agreed strategy. Ideally a mix of institutional players facilitates the enactment of new 'enabling policies' where strategies are difficult to implement. It may also be possible to streamline the process for approvals of projects that fit new directions. Ultimately a collaborative process may result in institutional reforms.

Research on collaboration suggests that some degree of collaborative process must exist within each group in order for the group itself to function effectively within a larger collaborative. Part of the difficulty is the collaborative participants can quickly become orphaned from their constituency, and thus unable to actually deliver on the new agreements. Where outcomes are important, then the best approach is to constitute a collaborative from the senior executives in each participating group.

Ecologies may offer lessons for the collaborative design process. A collaborative is composed of self-organising specialised cells that work together to create a larger physical body or organism. The communications channels are the nervous system that communicates information needed for the community to be self-aware and future directed (alive). The collaborative itself thus adopts the emergent property of mind at the scale of region, to control the networking, research and information flows.

The collaborative model may be a necessary response to the changing nature of urban regions and system design. However a major difficulty with adopting collaborative arrangements is the lack of any institutional structure to lead the process. Almost by definition no group or government has the mandate, funds or independence to undertake such a broad, out-of-control process. And without a champion, the process never gets started. Perhaps this explains why so few collaborative modes currently exist in urban regions.

One of the few exceptions is the Fraser Basin Council – a watershed-based collaborative organisation that is the principle forum for managing environmental conflicts and aligning sustainability plans for communities located along the Fraser River in British Columbia. (www.fraserbasin.bc.ca)

Urban experts from all parts of the world visit the Council to learn about successful collaborative process. The existence of the Council provided credibility and insight for the collaborative process that is described in this thesis. [citiesPLUS Governance Systems Foundation Paper 2002 www.citiesPLUS.ca]

Established in 1997, the Fraser Basin Council is a not-for-profit organization created to foster the sustainability of the Fraser Basin by implementing the vision and principles articulated in its Charter of Sustainability and monitoring state (health) of the Basin. It organises conferences on current issues, sets up task groups, publishes a state of the basin report with sustainability indicators, and conducts research with a small in-house staff. Under the direction a 36-member Board, the Council's governance achievements can be contributed in part to the Charter as it articulates many tenants of a good governance system – similar to the regime principles described by Krasner.

The Council's collaborative (non-binding) model of governance, and consensus-oriented approach, have mobilized a diversity of organizations and individuals to actively participate in this governance system, creating an informed and 'safe' table for dialogue and problem solving. Creating a forum for networking, research and information flow, and learning among its members encourages participation in and efficiency of the institution to establish a common future for the Basin. Under this system, the Council also succeeds in building participants' capacity to work well in collaborative governance processes of integrated systems management.

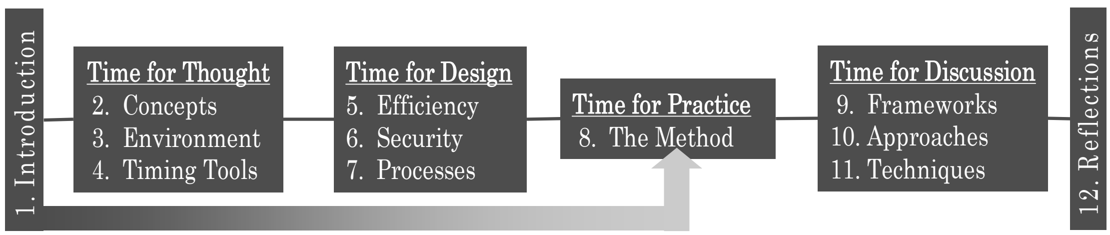
PART 3: TIME FOR PRACTICE

I thought that I knew cities well before this project, but through CitiesPLUS my awareness and excitement have increased immensely. I now believe that innovative long-term planning can lead to a true renaissance in urban thought and action. Cities are all about choices - choices that become reality very quickly, with lasting consequences. Over the 21st century - the urban century - much will depend upon getting the choices right. By sharing our experiences each of the teams in the IGU project can contribute to this renaissance. We can avoid horror stories of undrinkable water, unbreathable air, unaffordable housing and corrupt government, and instead see the vast majority of people on our planet living lives rich in dignity and enjoyment.

Mike Harcourt, Past Mayor of Vancouver and Past Premier of British Columbia 2003

8 What methods were used to explore the Practice of Long-term Urban System Design?

The practical research involved the creation of a research frame, the organisation of a series of workshops, a case study of urban system design, and the development and application of innovative timing tools. In this chapter each of these research activities is described.



8.1 A Generic Design Framework

The applied research began with the creation of a generic framework for urban system design. The framework represents a set of activities that may be sequenced in time, and also defined by reference to time. The framework was used both to direct the case study research described in this Chapter, and later as an organizational structure for presenting results in Chapters 8 and 9.

In its most simple form, an urban design framework can be represented as a pyramid that has, at its top, a unique "vision" for the project, neighbourhood or region. From this pinnacle, the framework divides into a spreading tree of elements, at increasing levels of specificity, until at the bottom it addresses how to implement and manage specific actions to achieve the vision. (Figure 69) Between the pinnacle and base, are one or more layers of analytical and creative design work. Such layers are nested, from abstract to practical, each providing a presumably logical progression to the more detailed layer below.

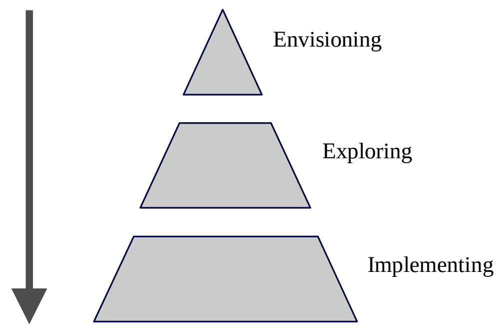


Figure 69 A rudimentary planning framework may have only three layers

A framework not only moves from abstract to specific, but also from long-term to short-term. The time dimension is implicit, since the very nature of design and planning is to manage a process of change to achieve an end result. Both the levels of abstraction, and the length of the time scale, are variable.

The basic three-layered framework of Envisioning, Exploring and Implementing can accommodate most design processes. In fact most of the activity that is usually referred to as 'design process' fits into the middle layer 'Exploring'. However, a more rigorous framework would include at least two additional layers: 'Scoping' or boundary-setting at the top, and 'Monitoring' or evaluation at the bottom. The result is a five-layered framework used for this research and referred to as SEEIM: Scoping, Envisioning, Exploring, Implementing, and Monitoring. (Figure 70)

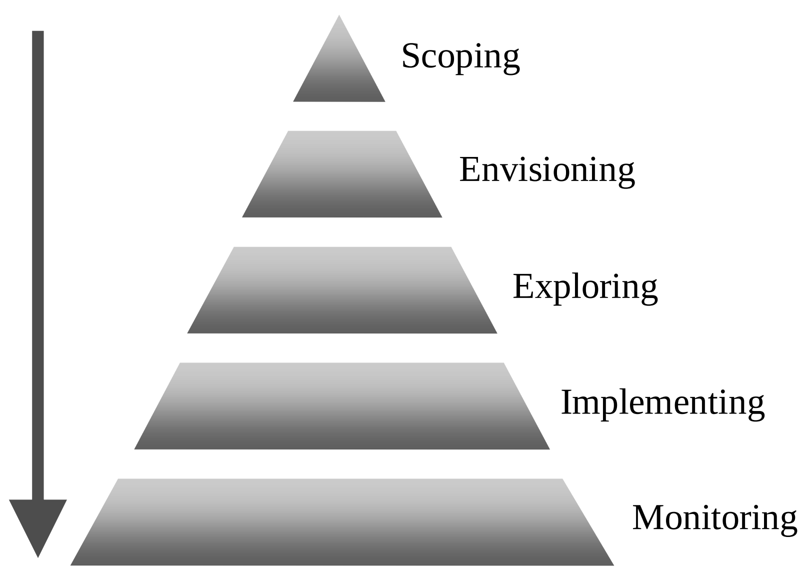


Figure 70 The five layers of a 'SEEIM' Framework provide a convenient means of organising the research work and tools

The precise number of layers within any framework can be expanded or contracted to meet the needs of the situation. Where the design exercise is complex, involving many elements and schedules, a more finely structured progression may be warranted. For example, the SEEIM Envisioning layer can be subdivided into Themes, Principles, Vision Statements, Goals and Targets.

A SEEIM framework can include any principle, goal or strategy that the user desires, and it can be moulded to fit almost any current planning ideology or terminology. In this sense it is a form of 'methodological pluralism' – anything and everything fits inside the framework.

Ideally a planning framework facilitates participation and communication in the design process, allowing anybody to examine the plan or design, at any layer, and then, at their own pace and initiative, move up – to discover the rationale, or move down – to discover how intentions are realised, or problems solved and evaluated.

Where many people are involved, as may be the case in participatory planning or an integrated design process, the connections between the layers of a framework need to become transparent to users and durable over time – with cross-referencing between consecutive tasks. For example a vision statement does not stand alone and proud, but rather is carefully unbundled and used to derive related goal statements. The goals in turn are used to select specific 'indicators of performance', which are used to express the goal in quantifiable terms – as targets. The targets are used to guide the choice of specific strategies, and so on. This rational hierarchy ensures alignment between the vision, at the top, and the actions at the bottom.

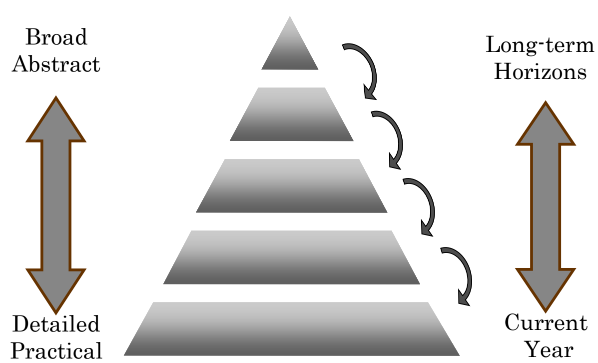


Figure 71 Alignment between the layers creates the rational connections between broad visions and detailed strategies, and between the long-term and the short

The design process is typically much more dynamic and intuitive than the simple progression represented in a linear, layered hierarchy. For this reason, design frameworks are often portrayed as an iterative series of steps that gathers depth and clarity with each rotation. As shown in Figure 72, such a spiralling process can occur within each layer of a framework, and then for the framework as a whole (charrettes, scenario modelling, pilots). Ideally the number of cycles in design is a factor that adjusts not only to budget, but also to the return on investment.

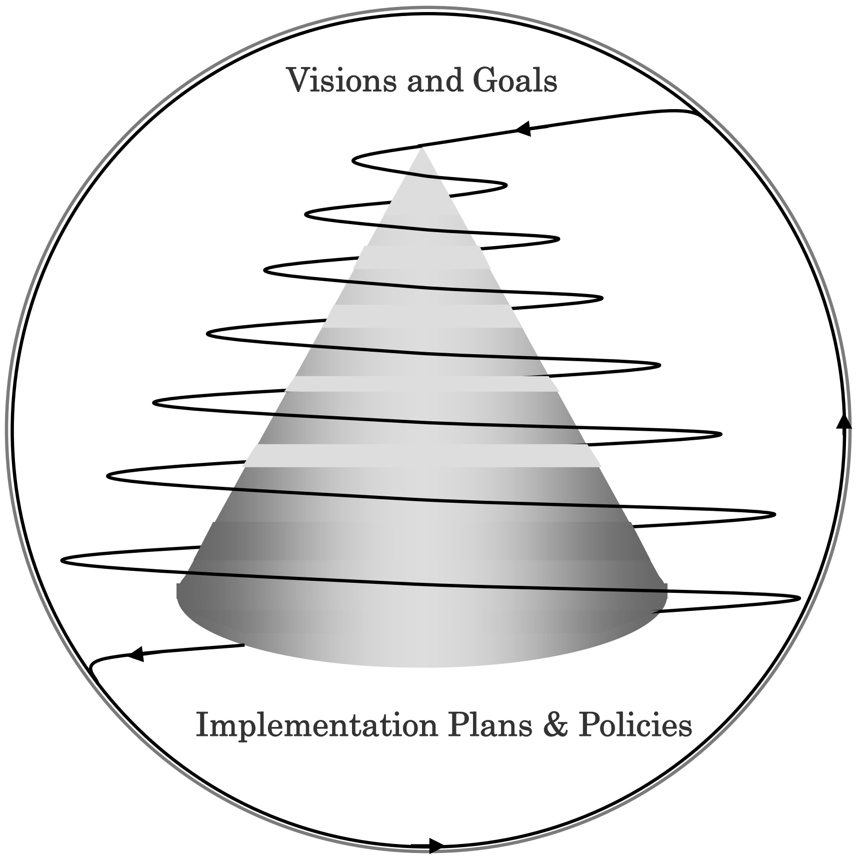


Figure 72 In practice, the design process tends to be intuitive, dynamic and iterative: a spiralling process adds depth to each layer and a cycling process permits evolution of concepts over time

Iterative processes are especially common amongst designers unconstrained by analytical methods or quantified targets. Rapid visualizations are created, and recreated again and again, until eventually solutions coalesce. Such intuitive design exercises are still guided by a framework, if only as unstated assumptions. In fact iterative or cyclical design processes cannot easily be sustained without carefully defined scope and depth, and depend even more on frameworks than a one-time-through process. The challenge is making the framework transparent and shared by all participants – a challenge that becomes increasingly important with larger, interdisciplinary design teams and longer-term, measurable design targets. It is for this reason that contemporary design exercises have a love/hate relationship with structured processes and frameworks.

As Punter and Carmona point out, design frameworks and policies try to use words to express what is predominantly conveyed through a visual, or certainly multi-sensory, medium. As a consequence frameworks are seen as essentially negative or anti-creative, obstructing the natural process of synthesis. From this perspective design is championed as "an intuitive, largely visual and artistic process, where self-expression is paramount. Such designers have little time for the view of design as a problem-solving process where a set of parameters may be defined, and consensus reached about the objectives or principles to guide a particular development." [PUNTER 94] Within this culture of design the evolution of design frameworks became especially problematic.

8.2 The *CitiesPLUS* Case Study

The applied research for this thesis entailed a comparative case study of long term urban systems design. Referred to as *CitiesPLUS*, the case study began with a international interdisciplinary workshop and urban design charrette, organised by the author in Maastricht, NL. Workshop proceedings[29] were prepared by the author and circulated for comment. The proceedings were then used to complete a more in-depth analysis, which was issued as a separate, summary document on the principles underlying integrated urban system design.[30]

The outputs from the Maastricht workshop were then woven together with two other initiatives: the *Sustainable Urban Systems Design* project – an international design competition launched by the International Gas Union; and the *Sustainable Region Initiative* - a planning initiative undertaken by the Greater Vancouver Regional District.

Sustainable Urban Systems Design

The International Gas Union (IGU) is an industry association representing the ~65 countries worldwide that use natural gas as a staple energy source. In 2001, under direction of the then current IGU chair in Japan, the association announced their plans to hold a *Sustainable Urban Systems Design* (SUSD) competition. The results of the competition would be unveiled as a centrepiece to the triennial World Gas Conference, in Tokyo 2003. The launch of an urban design competition reflected a change in

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[29] Proceedings of a Workshop on Sustainable Integration of Infrastructure and Buildings; Moffatt 2001; Part 1 includes mini-papers, presentations, and highlights of the discussions; Part II includes the detailed results of the hypothetical case studies created during the charrette; Part III includes a summary for local governments titled .

[30] Summary document is titled: "Closing the Loop: A Guide to Green Infrastructure for Canadian Municipalities" 2002 and is available at www.sheltair.com April 06.

thinking within the association. At the dawn of the new millennium, the IGU looked ahead, and estimated that conventional gas reserves worldwide would be exhausted in 60 years. They also recognised that climate change and the expansion of urban infrastructure were likely to become major forces driving investments over the next few decades. In this context, they concluded that the IGU mandate for the 21st century should be expanded to include assisting cities with using scarce and diminishing gas resources as a bridge to sustainable energy systems.

The SUSD was to be the first international design competition for sustainable urban systems. The terms of reference for the competition were especially unique: in essence each competitor was to envision a transformation of all urban systems towards a vision of sustainability, staged over 100 years, for an existing metropolitan area. The competing teams would have approximately two and one half years to complete their submissions. They would meet and exchange views mid-way through the process, and then submit 50-page summaries, with technical attachments, to a panel of 8 eminent judges, each from drawn from a different nation and professional discipline. The teams and judges would then gather for a day of public presentations in Tokyo, prior to the release of the judges' commentaries and awards.

IGU staff worked with regions around the world to finalise the selection of teams. In Canada the Canadian Gas Association (CGA) was proactive, convincing IGU to allow two teams from North America – one from Canada and the other from the USA. Many of the participating international regions, including Canada, held extensive internal competitions to evaluate their options and select a suitable Team. Eventually 9 teams were formed, representing specific metropolitan areas in Japan (2), India, China, Europe, Argentina, Russia, USA and Canada. Most teams included a combination of academics and practitioners, and were supported by staff and elected officials from their candidate urban region. Each team was required to have a single team leader.

The Sustainable Region Initiative

Canada's first Sustainable Communities conference, in November 2001, brought together many elected officials and senior staff from local governments across the country. One of those attending was the Chief Administrative Officer (CAO) for the Greater Vancouver Regional District (GVRD), who upon his return to Vancouver decided to launch the "Sustainable Region Initiative" (SRI) – with the object of aligning the region's growth strategy and land use plan, and all other regional plans, with the principles of sustainability. The SRI engaged the entire regional staff – approximately 1100 individuals – and the elected officials in a process of analysis and collaboration. As part of the launch of SRI the presentation on sustainable urban systems was repeated for the GVRD board, and again for the Council of Councils (all elected representatives of local, regional, provincial and federal levels in Greater Vancouver).

Greater Vancouver's system of government is unlike other major metropolitan areas in Canada in several important respects. While almost all other large metropolitan areas in North America have amalgamated into a single administrative unit, Vancouver has not. Instead, it has retained a structure known as the Greater Vancouver Regional District (GVRD), comprised of some twenty-one municipalities. Its mandate includes regional scale potable water, wastewater, household solid waste, air quality, land use planning, growth management, major roads, and regional parks. The total urban area is 10,000 square kilometres, and is home to 2 million people, projected to increase to 4.3 million by 2030.

The GVRD's ruling authority, the board, is drawn from the municipal councils in the region. In this sense it operates as a federation of municipalities, using a process of "upward delegation," which implies that it can only encourage action on the part of its member municipalities, not enforce it. It also means that the various municipalities making up the GVRD often have different legal regimes. The City of Vancouver, for example, is unique in retaining its own Charter. Individual municipalities often develop their own initiatives and responses to problems and issues, even when the issues transcend administrative boundaries. Thus while the Regional District approach to governance has the advantage of keeping the policy-making process within local communities, it may mean that issues needing a fair degree of coordination and planning among the various municipalities are slow to be adopted and have mixed success. For this reason a major effort was required by the GVRD senior staff to garner the necessary political support to launch the SRI.

Once the SRI was underway, the author was invited to join the GVRD staff committee that was responsible for directing the planning and design exercise. As the only external researcher and advisor on the committee, the position offered an unusual opportunity to witness the process of sustainable urban region design from within the administrative arms of regional government and the associated civic utilities. It was an opportunity to prepare a case study and document the results and the learning. In this sense the SRI was a chance to expand upon the Maastricht workshop and charrette, but in real time, and with a real metropolitan area.

The SRI case study work included attending regular meetings, interviewing staff within regional government and utilities, participating in a series of formal planning events with experts and decision-makers, and presenting background information on sustainable design issues. The SRI process began with a scoping and visioning exercise, and included a public communications campaign.

The Case Study is formalised

The author was requested by the Canadian Gas Association to build upon the Maastricht workshop and assemble a candidate 'Team Canada' for the SUSD competition. Greater Vancouver's SRI made the region an obvious choice as a case study. A marriage of the SRI and SUSD was viewed as serendipitous by the regional and national groups in Canada. The competitive nature of the IGU project would allow Greater Vancouver to involve a greater number of experts and advocates, and to explore more innovative and far-reaching scenarios than would normally be possible for a strictly regional government initiative. Thus the GVRD was selected to represent Canada, with the author assuming the role of National Team Leader. The very close involvement of the local governments in 'Team Canada', and the on-going SRI work, meant that the long-term urban system design was not only a competition and research experiment, but a very real exercise in long-term thinking for urban system design. In the words of GVRD's Director of Planning and Policy "We were shooting live bullets."[31]

To permit greater freedom in design and management, the SUSD work by Team Canada was mostly conducted as a parallel exercise to the SRI. GVRD agreed to participate as one member of an ad hoc collaborative, and in this way avoid making local politicians accountable for outcomes. Nevertheless a very strong connection was maintained between the SRI and the SUSD. The same government staff participated in both exercises, with the most senior staff at GVRD participating as members of the SUSD advisory board. The work in progress was shared. Within the GVRD the SUSD was characterised as the 'long-term' component of the SRI.

The SUSD team for Canada adopted the name *CitiesPLUS*. '**PLUS**' is an acronym for **P**lanning for **L**ong-term **U**rban **S**ustainability. PLUS is also a term indicating positive value (+), and thus the acronym also conveys the potential for a 'positive' contribution from adopting long-term horizons.

As the *CitiesPLUS* team leader, the author was in a position to direct and develop one of the world's first long-term urban system designs for an existing metropolitan region. The case study could build upon the foundations of many different strands of long-term planning theory and design – especially regional planning, comprehensive planning, ecological design. It also presented the opportunity to explore the full range of timing tools, from decision trees and technology scans to scenario planning and

[31] Statement by Ken Cameron, GVRD Director of Policy and Planning, 2003

simulation modelling. The extremely long time horizons, broad scope and regional scale meant that the exercise was relatively unique in the modern era.

Thus the *CitiesPLUS* case study provided laboratory for exploring the time concept and the role of time scales in the urban design process. It required experimentation with a variety of analytical methods and tools, and the process of design and communications within a large, diverse community of professionals and advocates. Consequently an important element of the research method entailed 'reflexive action' – developing knowledge through practice.

The case study began with assembling a suitable team of advisors, experts and assistants. Although many of these people were busy professionals, and were considered leaders in their respective fields, virtually everyone who was asked agreed to participate. An advisory board was constituted from VPs or presidents of the local utilities: electricity, gas, water, waste, transportation; other directors were drawn from local and national government departments, civil sector groups and university institutes. The advisory board was chaired by the Honourable Lloyd Axworthy, Director of the Liu Centre for Studies in Global Change at University of British Columbia, and past external affairs minister for Canada. The vice-chair was the Honourable Mike Harcourt, past mayor of Vancouver and past premier of British Columbia. The involvement of these senior statesmen, along with the competitive nature of the project, probably helps to explain the willingness of so many participants to donate their time.

The design work began with the development of a generic planning and design framework – the SEEIM framework – which organised the design process into five primary stages or layers: **S**coping, **E**nvisioning, **E**xploring, **I**mplementing and **M**onitoring. Over the course of the research this basic framework was adapted to accommodate much greater detail and a dynamic process. Ultimately the framework itself evolved to become a tool for comprehensive planning, integrated design, collaborative process, and adaptive management.

The SEEIM framework was documented early in the *CitiesPLUS* exercise, and used both as an experimental tool to guide the research and design process, and later as a structure for presenting the *CitiesPLUS* design results. The SEEIM framework was shared with the Chief Operating Officer of the GVRD, who chose to adopt the same basic framework as a structure for the parallel work occurring as part of the SRI.

The composition of the design team reflected the broad scope of the design mandate. A method was adopted for categorizing the urban sub-systems. Ultimately eighteen systems were identified for inclusion, each examined by a separate sub-team. Each sub-team was structured as a collaborative from different sectors, including senior academics, private practitioners, advocates from civil society and staff or elected representatives from local and senior governments. Each team was chaired and directed by the author, and each team participated in the design at each level of the framework. Each team also provided representatives for each of the major design events.

Other urban regions in Canada were contacted for advice, and invited to visit Vancouver and participate in a *CitiesPLUS* symposium at the University of British Columbia. The three-day symposium, titled *The City in the World,* involved mayors, councillors and senior planners from Greater Vancouver municipalities and from thirteen other urban regions across Canada. Prior to the symposium the author prepared a discussion paper titled: "*The City in the World: Planning in the Face of Increasing Uncertainty*" which focused primarily on the types of changes that can be expected over 100 years, and the possible need to re-define sustainability to include the concept of resiliency. [MOFFATT 2002] Each city responded to the discussion paper by means of written and oral presentations at the symposium. Representatives also contributed additional advice as part of break-out sessions on specific topics

As Team Leader, the author facilitated the plenary sessions at the symposium, and coordinated the discussions and panel sessions. The results of the symposium were summarized in a final proceedings [*City in the World Proceedings Summary, September 17-18, 2002*] and were circulated for comment to all participants.

Within Greater Vancouver a regional network was created to facilitate input from a broad range of private and public organizations. This *CitiesPLUS* regional network encompassed 60 members, including advocacy groups, consultancies, NGOs, institutes and associations. The network gathered at early morning workshops which occurred every 2 months, and allowed for input at each level in the design framework. The author facilitated these 'Networking Breakfasts', and arranged for a keynote presentation, a panel of commentators and a break-out session for round-table discussions or design exercises. Minutes were kept from each session, and the highlights were incorporated into a *CitiesPLUS* newsletter that was published and distributed approximately every quarter[32]. Altogether approximately 500 experts were directly involved in the design process[33].

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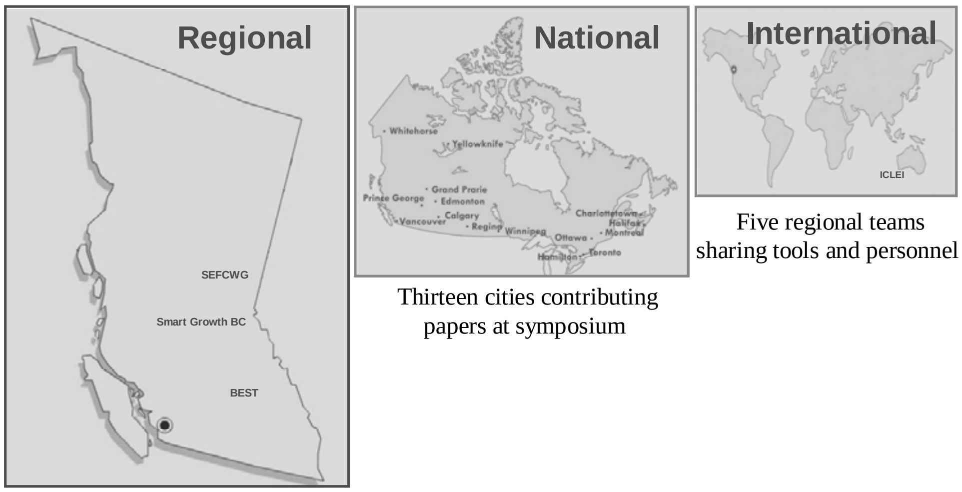
[32] *CitiesPLUS* newsletters available from The Sheltair Group, 205 1525 West 8th Ave Vancouver Canada V6J 1T5, or online at http://www.*CitiesPLUS*.ca March 2006

[33] Participants have been identified by name on the final page of the final submission: *CitiesPLUS* 2003.

An effort was made to also extend the networking to the international level, by contacting cities worldwide who were interested in long-term design methods. The Advisory Board helped design a process for continuing such a network past the SUSD project, and for including as part of the plans a proposal to the Canadian government to host the U.N. World Urban Forum in 2006 in Vancouver. In this way the networking exercise extended over three scales: regional, national and international, as shown in Figure 73.



60 Community Organisations

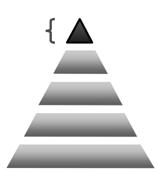
Thirteen cities contributing papers at symposium

Five regional teams sharing tools and personnel

Figure 73 *CitiesPLUS* entailed dialogue within networks at three scales

As team leader, the author attempted to design and execute a process that would engage the networks of experts and advisors throughout the project. This included chairing all meetings with the sub-teams and networks, presenting the evolving design ideas to other researchers, facilitating special events, and directing a core research and design team. Research assistants and other graduate students assisted with specific tasks, and especially with the development of appropriate methods and tools for analysis and communication. The systems design research was executed as a series of mini-projects, staged over time to correspond with the layers of the SEEIM framework.

8.2.1 Scoping Methods



As with any design exercise, scoping serves to establish current conditions and to define boundaries for what is to be included or excluded from the analysis. In *CitiesPLUS* scoping also involved collecting and analysing sufficient background information for supporting the design process. Scoping urban systems can be the most time consuming and resource intensive layer in a design exercise. In *CitiesPLUS* the scoping research occupied approximately one third of the total time. The intense level of effort required was a surprise to everyone involved.

Scoping was addressed in three steps. The first step, boundary-setting, included a categorisation of urban systems, identification of potential participants, selecting clear and appropriate temporal and spatial scales, and identifying essential outputs. Attention was also given to the types of information that would need to be accessed, and the expected human and capital resources available to the design team.

The second step, inventorying (or surveying), included identifying and collecting existing information on the selected urban systems. For a baseline inventory, a 'Foundation Paper' was prepared on each of the 18 selected urban systems. The Foundation Papers were produced in parallel, over a period of four months, and were ultimately distributed on the *CitiesPLUS* web site [www.*CitiesPLUS*.ca]. For easy cross-referencing the first Foundation Paper, **Materials Management**, was used as a template for all the others, and thus each paper follows a similar format, including historical background, trends, baseline analysis, methodological approaches, existing facilities, management policies, political issues, thresholds, constraints, opportunities, indicators, references, key players and - to guide future research - a review of opportunities to participate with other jurisdictions and other processes.

Materials Foundation Paper, CitiesPLUS

CONTENTS

- Foundation Overview
- Historical Background
- Trends in Material Recycling in the GVRD
- Current Baseline
- Approaches to Material Flow Systems
  - Material Inflows
  - Material Outflows
- Infrastructure
  - Current Waste Management Infrastructure
  - Solid Waste Infrastructure
  - Recycling and Reuse Infrastructure
  - Landfill Gas Generation at Greater Vancouver Landfills
- Policies, Programs and Regulatory Tools
  - Region
  - Greater Vancouver Cities
  - British Columbia
  - Canada
  - Comparisons and Examples from Other Jurisdictions
- Issues of Concern
  - Environmental
  - Social
  - Economic
- Thresholds
- Constraints
- Opportunities
- Current Indicators
  - The Ecological Footprint
  - Dematerialization
  - Sustainability Indicators for Material Flows
  - MIPS (Material Input Per unit Service)
- References
- Appendix A: Opportunities to Engage with other Jurisdictions
- Appendix B: Key Players
- Appendix C: Key Literature, Publications and Events

Figure 74 Foundation Papers for each urban system followed a common structure

The background information for each Foundation Paper was prepared by experts within the core team, and then integrated with the new material on visions and goals. Thus the Foundation Papers became combined reference material and original research, and reflected a consensus reached by the mini-collaborative. As a group the papers become a matrix where the content headings intersect with each of the urban systems, creating a standardised, multi-disciplinary knowledge base on the urban systems.

The third step included a future scan, for the purpose of identifying external forces likely to impact urban systems over the long-term. Six forces were identified: Climate Change, Technological Change, Demographics, Globalization, World View Shifts and Resource Scarcities. A variation of SWOT analysis (Strengths, Weaknesses, Opportunities and Threats) was completed, examining each force from an 'all-threats' perspective. The six scans were summarized as a series of reports suitable for sharing with the sub-teams, and distributing via the web site. Each report followed a common template, including three perspectives: historical patterns, mega-trends, and implications for urban futures (Figure 75).

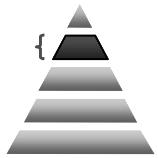
Technological Forces Paper, CitiesPLUS

CONTENTS

- Introduction
- Historical Patterns
  - History of Cities and Technology
  - The emergence and growth of cities
  - Communication and military technology
  - Transportation technology
  - Energy technology
  - Conclusions regarding the intertwined history of cities and technology
- Technological Innovation Patterns
  - Basic innovations and improvement innovations
  - Basic innovations created and transformed cities
  - Low cost factors drove innovation waves
  - Basic innovations changed technological performance
  - Technology changed economic system patterns
  - Innovations changed social paradigms
  - Cities and the innovation 'outsider effect'
  - Dissemination of technology: an S-shaped curve
- Critical Trends
  - Mega Trends
    - 1) From linear to non-linear assumptions
    - 2) From economies of scale to economies of scope
    - 3) From physical to virtual connectivity
    - 4) Declining birth rates in the north
    - 5) Increasing ecological footprints
  - Innovation meta-trends
- Implications for the Future
    - Reversing trends to shrink city footprints
    - Planning for transformational performance
    - Developing distributed, complex and redundant systems
    - Opening to outsiders

Figure 75 The content of the Technology Forces Paper followed a common template for all six of the scans

8.2.2 Envisioning Methods



Envisioning is the level of design that first introduces a conscious intent to influence future events. If the design details are blueprints, then the vision is more like an artistic rendering. It serves to inspire, guide and hold accountable. It is a normative process that both recognises and intervenes in the value system of community participants. "A design will never be greater than the vision that guides it."

To begin the process of Envisioning the author led a series of half-day design workshops, engaging each of the eighteen sub-teams in series. The agenda for these 18 workshops included an orientation on long-term design methods, a review of future forces, a SWOT analysis, an introduction to the design framework, a group visioning exercise, and the preparation of specific goals and associated targets. A series of follow-up workshops and conference calls was necessary to finalise visioning, and to allow groups to review and edit the evolving content of their Foundation Paper.

To assist the visioning by sub-teams, a generalized set of principles was drafted and introduced at the outset of each workshop. [*Cutting to the Core Principles of a Sustainable Urban System,* 2003 www.*CitiesPLUS*.ca] Principles, like ethics, are broad value-based rule statements (e.g. the precautionary principle) that are intended to guide decision-making at all levels of the framework. The *CitiesPLUS* principles were used to help in setting priorities and making difficult choices while defining goals and targets.

Vision statements were drafted by each participant in each sub-team, and then rolled up, first to a systems level, and later to an overarching vision statement for the urban region. [*Visions for Greater Vancouver*, www.*CitiesPLUS*.ca] The vision statements describe images of a desirable future, using a simple sentence structure to keep the important thoughts distinct. As part of the visioning, participants were asked to identify particular assets and strengths upon which the region could build. Sub-teams were also asked to identify the greatest potential risks and barriers to success of the vision, including a list of the top vulnerabilities and any unique threats within each urban system.

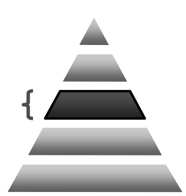
Each sub-team worked to unbundle its vision into a discrete set of long-term goals, intended to explicitly express the ideal conditions or qualities that are part of the vision. Typically the sub-teams produced a list of 5 to 15 goal statements. These statements were later edited by the author and circulated for review. [*End-State Goals for Greater Vancouver*, 2003, www.*CitiesPLUS*.ca] The goals define the ultimate condition desired, and sometimes the direction of change that is needed. In general an effort was made to avoid confusing strategic directions (e.g. more diversity) with ultimate goals (e.g. security). Altogether the teams produced a list of 206 goal statements. "*Maintain and enhance the ecological functions of the site"* is an example of a goal.

Envisioning also involved selecting objectives or targets - short-term and mid-term – for use in framing the pace of change for the region's movement towards the goals. Target-setting required that performance indicators be defined for specific goals. Performance indicators quantify the impact of specific actions, and therefore help to gauge progress, and manage the pace of change. Many indicators were found to serve more than one goal.

In order for the sub-teams to understand the indicator as a measurement tool, and to set targets, benchmark values were researched and then presented on comparative scales, with hyperlinks from each benchmark to background information. Benchmarks provide the comparisons - without which any form of measurement is meaningless – and can greatly expedite the target-setting process. Benchmarks for regional indictors can include historical performance of the regions; comparisons with neighbouring regions, best performing regions or international locations; targets set locally or by other regions; industry standards or best practices; threshold values or fixed constraints.

As part of the research a software visualisation tool was designed and developed which served to automatically generate benchmark scales, and which was intended to manage a database of benchmarks values and linked background information for each indicator. With research assistance from the core team[34], targets and benchmark scales were created for 56 indicators in *CitiesPLUS*. [*Indicators and Targets for Greater Vancouver*, 2003, www.*CitiesPLUS*.ca] Benchmarking for *CitiesPLUS* proved to be time-consuming and difficult, due to the scarcity of data and a lack of standardized metrics.

8.2.3 Exploring Methods



Exploring is process of evaluating alternative design strategies for achieving targets and goals. This translates into a repetitive process of researching the options, testing against evaluation criteria, and comparing results. In *CitiesPLUS* all types of timing tools were employed in the research, including narratives, foresight, decision guides, models and scenario planning. Two timing tools became

[34] A majority of the research on precedents and comparative benchmarks was undertaken by Lyle Walker of The Sheltair Group .

especially important to achieving consensus on a long-term design: multi-dimensional scenario analysis and systems design charrettes.

Scenario Analysis

The scenario analysis began with the identification of those systems suitable for modeling and analysis, and with the creation of a framework for integrating various scenario tools into various layers of the design process. A frame was needed because among the sub-teams some confusion existed around the meaning of scenarios and the appropriate use of such modelling tools. The *Decision Support Systems* sub-team debated these issues, and an appendix to their Foundation Paper addresses how tools can be integrated into the SEEIM framework. [*Decision Support Systems for Greater Vancouver*, 2003, www.*CitiesPLUS*.ca]

The bulk of the modelling work focused on energy, water and materials flow analysis at the urban region scale. Data was collected from the region, the municipalities, the utilities and other *CitiesPLUS* partners to permit a hybrid analysis, bottom up and top down. For this purpose the author developed software for visualizing the all these regional systems as Sankey diagrams. The Sankey software: *MetaFlow ver1.1*, was used to quantify and automatically draw the current and future urban metabolic flows for energy, water and organic materials in Greater Vancouver.

Backcasting scenarios compared the effectiveness of different strategies relative to a business-as-usual (BAU) scenario. For example, a future energy system based primarily upon an electricity grid was compared with a system based upon a hydrogen grid, and then conclusions were circulated to the appropriate sub-teams for review. Eventually reports were produced on Backcast Pathways for both energy and water systems. [*The Story Behind the Water Backcast Scenario*, *The Energy Backcast Scenario*, 2003, www.*CitiesPLUS*.ca] The backcast reports included a discussion of targets, trends and strategic approaches. The energy backcast included estimated impacts on air quality, greenhouse gas emissions and economic costs. Both the energy and water backcasts projected the demand and supply by sector and cumulatively, for a 100-year period. A preferred pathway was proposed, including a list of measures by sector, along with a discussion of associated benefits.

The analysis of different scenarios over the long-term, and the integration of land use and physical planning with energy and water systems, introduced so many variables that the research and design process became highly complex and thus difficult to execute. In the case of scenario development, a step-by-step guide was created to rationalise an approach to pathway development. This approach prioritises strategies based upon their potential for synergy and 'whole-system' solutions. For example demand management options are addressed before supply system options.

[*The One-System Approach*, 2003, www.*CitiesPLUS*.ca] A number of other innovations were introduced to cope with complexity, some of which are described in subsequent chapters.

The backcasting pathways were initially structured to meet the arbitrary goal of sustainability in 100 years. In some cases a preferred scenario was proposed as a way to meet goals in periods of less than 100 years. As part of the modelling exercise an assessment was made of benefits and costs. Critical path planning was used to explore how to stage the scenarios for different systems. The pace of change was addressed, in terms of benefit cost analysis, and an estimate of risk to determine what might constitute excessively slow, or rapid, transitions.

Goals and targets for many of the systems included adaptability and resiliency. As a consequence, forecasting scenarios were used to assess the vulnerabilities of existing urban systems to a full range of threats posed by external forces. The forecasting of long-term risks required the development of new analytical tools. These tools were used to identify the chains of 'cause and effect' that could lead to economic, social or environmental impacts for people in the region. The design and use of such forecasting tools will be described in subsequent chapters.

The intent behind the forecasting scenarios was firstly to design systems more suitable for the expected future; and secondly to design systems to be more adaptable and shock resilient in the face of myriad threats posed by the six driving forces. Special attention was given to assessing the vulnerability of systems to hazards associated with climate change. Global climate change models predict Greater Vancouver will experience warmer temperatures, wetter winters, dryer summers, more intense storms, rising sea levels, and more frequent extreme weather events. A separate report was produced which outlined the effects of these changes on specific urban systems, and identified strategies for 'breaking' those cause-and-effect chains that lead to negative impacts. [*Climate Change Impacts and Adaptation Strategies for Urban Systems in Greater Vancouver*, Volumes 1 & 2, 2003, www.*CitiesPLUS*.ca]

Systems Design Charrette

The second tool for Exploring was the 'systems design' charrette – a variant of the tool first used in the Maastricht workshop. In *CitiesPLUS* the charrette was a tool used both to stimulate creative interdisciplinary thinking, and to generate a library of graphics and schematics.

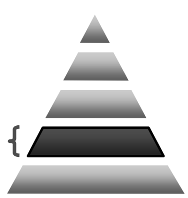
Traditionally charrettes have been used as a design tool principally at the scale of buildings or building developments, and sometimes as the scale of neighbourhoods, but almost always from a perspective of built form and questions of livability and transportation. Integrating the full range of urban systems over a long time period for an urban region posed a more complex challenge.

Hosted by Simon Fraser University, the first *CitiesPLUS* charrette involved 60 professionals, split into four interdisciplinary teams. One or more members from every sub-team participated in the first *CitiesPLUS* design charrette. The charrette teams also included handpicked members from the Greater Vancouver professional design community. A pair of landscape architecture students with drawing talent supported each team. One team worked at the regional scale, and the others were each given a prototypical neighbourhood - from inner city to suburban. The assignment was to stage a transformation to sustainability for all urban systems and buildings, with milestone plans and drawings for ~2030 to 2100.

The author began the charrette with an orientation session, summarising results of the foundation research. The charrette was jointly facilitated by the University of British Columbia School of Landscape Architecture, and the *CitiesPLUS* core team. Design work by teams took place over three full days, interspersed with mini-presentations by outside experts. The charrette concluded with team presentations to the whole, and presentations to a panel comprised of members of the Advisory Board.

After the charrette, students assisted further with polishing the visual outputs. A final publication was produced in two parts: Part 1 was a manual on how to organise and deliver a charrette for urban system design. Part 2 of the charrette publication was a summary of the *CitiesPLUS* charrette event, with highlights from all the team presentations and designs. [*Tools for Planning for Long-term Urban Sustainability: The CitiesPLUS Design Charrettes*, 2003, www.*CitiesPLUS*.ca]

8.2.4 Implementing Level

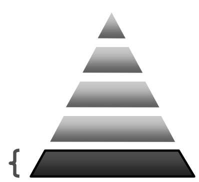


Implementing is the level of the SEEIM Framework that translates the preferred strategies into actions and designs. The actions may include the use of any policy tools deemed appropriate. The designs may include new programs and new infrastructure, including pilot and demonstration projects.

The *CitiesPLUS* research attempted to identify appropriate implementation measures for each urban system. Initially these were defined as 'best practices' or innovations, and were applied in concept to prototypical neighbourhoods. Each set of practices formed a separate layer of changes to a basic structure of buildings and streets. At this more detailed level of the framework the design process became mired in complexity. Each urban system appeared to benefit from numerous measures, each in turn consisting of multiple practices and/or technologies. Methods were developed for simplifying implementation planning, for the purpose of defining strategic priorities and coordinating policies and actions across the broad scope of actors. Visualization tools were also developed to allow for integrated views of new actions.

Implementation methods also required that a process be put in place for integrating the SRI and *CitiesPLUS*. This process culminated with two types of activities. Firstly, the author presented key results and insights to groups of decision-makers, discussed the issues, and circulated reports. These feedback sessions included presentations to three of the city councils within the Greater Vancouver region, to the chief engineers for all cities, to head planners for all cities, to the GVRD board, and to the citizens Planning Council for Vancouver. Secondly, the GVRD initiated an internal set of workshops for briefing their staff. Actual implementation of the long-term systems design was delayed by a change in the elected leadership for the region, which occurred shortly after completion of the systems design.

8.2.5 Monitoring Level



Monitoring is about ongoing measurement and observation for purposes of feedback, evaluation and learning. In theory, feedback and evaluation in urban design is part of a continuous improvement process that is integrated into the management and maintenance of the urban systems. In *CitiesPLUS* it was not possible to commence monitoring since implementation was still in progress. Instead an effort was made to define how monitoring would ideally be incorporated into the management of the urban system, and the maintenance of the system elements.

The extended time scales of the *CitiesPLUS* design required that monitoring be redefined as a periodic process. By cycling through each layer of SEEIM framework at variable rates, the framework can be transformed into an 'adaptive management' framework. The research into monitoring level was focused on how to transform the design framework to accommodate continuous learning and an adaptive approach. Recommendations for a new adaptive design framework were prepared and presented to municipal leaders, and then incorporated into several reports on frameworks for long-term urban design. [The Adaptive Management Framework, 2003, www.*CitiesPLUS*.ca]

8.2.6 Documentation and Comparative Evaluations

After 18 months of research and design, the research and design work on urban systems was compiled and summarised by the author into a 50-page overview document[35]. [*A Long-term Design for Greater Vancouver*, 2003, www.*CitiesPLUS*.ca]. At the same time, the author prepared supporting technical documentation, including 15 separate reports. With technical support from two web-designers, the author also produced an interactive CD ROM version of the 100-year design. The CD transposed the summary document into an interactive presentation linked to the technical documents, and supported by a number of interactive visualisations. Finally the author scripted and illustrated a 30-minute audio visual presentation for presenting the final design to local decision-makers and to international audiences.

Subsequent to the competition, it became possible to review and compare the submissions by the other eight international teams engaged in 100-year system design, all of which were published by the IGU. [ITOH 2003]. Each of the teams was contacted to obtain their background reports. These submissions can be viewed as comparative case studies of how extended time horizons impact urban system design. As case studies, they cover a broad spectrum of cultures, climates, geography, living standards, building stocks, rates of growth, and access to resources. In the size category alone, the regions vary from mid-sized 'central place' cities like Vologda and Mishima, to metropolitan regions of 2 and 4 million like Vancouver and Berlin, to megacities like Buenos Aires at 13 million and Tokyo at 25 million. Despite these many differences, and despite a lack of any substantive communications between the teams, a review of the SUSD submissions revealed a number of common themes and approaches, challenges and conclusions, as described in subsequent chapters.

The review of the international case studies also suggested that a more collaborative approach internationally could offer potential for continued learning, and for development of a common approach based on the emerging new methods and tools for long-term design. With support from IGU, the author organised a series of follow-up workshops and charrettes involving 5 of the international teams: EU, Canada, China, India and Japan. These collaborative workshops provided a forum in which to embellish and standardise the 100-year designs, and to develop a method for translating long-term designs into detailed 30-year pathways and 5-year project plans. This collaborative phase of research with the international teams was referred to as *Bridging to the Future* (BttF)[36].

Workshops with the five teams included an exchange of software tools, seminars on methods and tools, and field audits of six reference buildings in

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[35] Approximately 50% of the report was written by assistant researchers.

[36] www.bridgingtothefuture.com April 2006

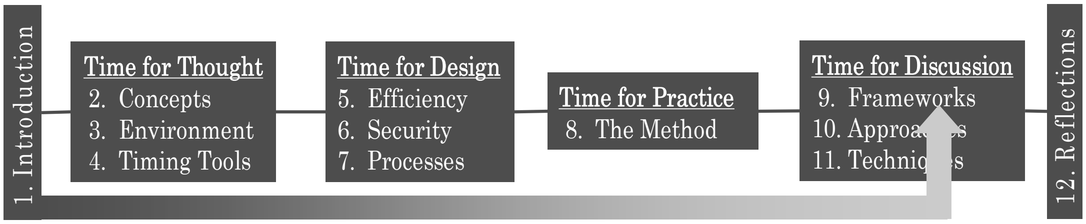
each case study city. In addition, the five teams came together on four occasions: firstly to review the methods as a whole; secondly to participate in system design charrettes in Groningen, in the northern Netherlands; thirdly to participate in a systems design charrette in the Qingpu District of Shanghai, China; and fourthly to participate in a conference and one-day workshop on long-term design methods in Amsterdam. The two charrettes were each one-week in duration, and facilitated by the author in accordance with the *CitiesPLUS* charrette manual and methods. These follow-on design exercises focused on long-term pathways for energy and water systems.

PART 4: TIME FOR DISCUSSION

After 100 years of debate on how to plan the city, after repeated attempts – however mistaken or distorted – to put ideas into practice, we find we are almost back where we started. The theorists have swung sharply back to planning's anarchist origins; the city itself is again seen as a place of decay, poverty, social malaise, civil unrest, and possibly insurrection. That does not mean, of course that we have got nowhere at all: the city of the millennium is a vastly different, and by any reasonable measure a very much superior, place compared with the city of 1900. But it does mean that certain trends seem to reassert themselves; perhaps because, in truth, they never went away.

Peter Hall, "Cities of Tomorrow" 1987

9 How do New Time Concepts Impact Conceptual Frameworks for Design?



9.1 How did 100–year Horizons Influence the Design Teams and the SEEIM Framework?

9.1.1 Bi-directional Time Scales

In the process of attempting to plan for a longer time horizon it was discovered that time extensions in urban design operate as a scale, rather than a milestone. Scales are bi-directional, not unidirectional. Thus the 100-year scale lies in both the past and the future as shown in Figure 76. This 'long view' borrows from both historians and visionaries.

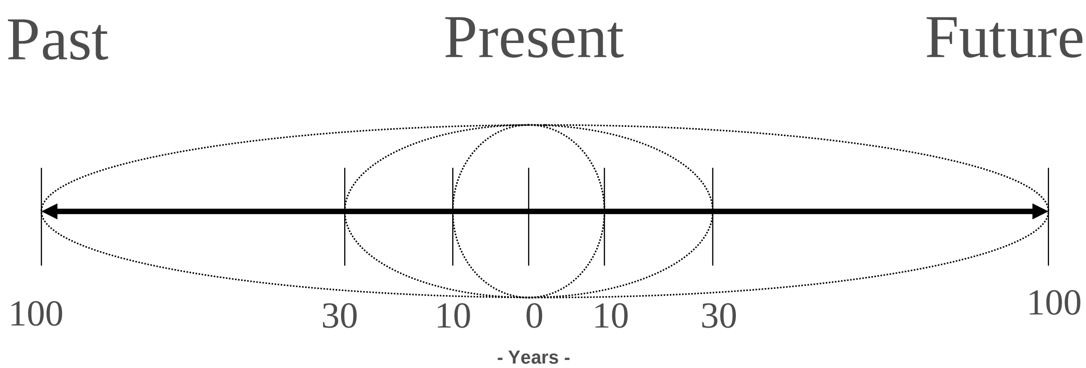


Figure 76 Long-term time scales are bidirectional - with horizons in the past and future

Initially the focus on the past was something of a surprise for the participants. It was assumed that 100-year horizons would result primarily in a futuristic and visionary exercise, researching and planning extremely modern - yet sustainable - solutions. But almost the opposite result is observed, as all the SUSD teams began with much more detailed historical research than is normal for urban design exercises.

The historical focus appears to serve at least two key functions. Firstly, it provides a natural measure (sometimes misleading) for gauging what a century-long time period implies for the possible scope of change that can occur in cities over a similar period in the future. Secondly, a historical perspective provides the normative context for utopian visions. It the words of Bryson and Crosby, it serves to merge political rationality with technical rationality.

A bi-directional time scale provides an expanded pallet of possibilities. As future time horizons expand, not only does the level of uncertainty increase, but so does the level of choice. Almost anything seems possible 100-years out. This means that much more attention must be given to what is really desired as an end result (the goals). Essentially an extended time scale forces designers into a value-based exercise. The design group must look closely at what they – or their community - represent and believe, since this is possibly the only valid basis for setting priorities and defining a common destination. They must ask: What are our traditions? What is worth preserving? What are our most basic values? strengths? beliefs? dreams? What has lasted over the long-term and is thus likely to persist? What legacies do we want to preserve for our children? What have we lost that should be recovered? All such questions root the design exercise in historical analysis. Perhaps the natural tendency for utopian design is to seek a romantic union of the best of all worlds, past, present and future.

Of the nine SUSD submissions, eight included a discussion of 100-year histories and design solutions rooted in historical patterns. Figure 77 includes figures from the submissions for Russia, Germany and China. The long-term plan for Vologda is to recreate the streetscapes and architecture of 19th century Vologda, - removing most of the Stalinist forms that now populate the city, while simultaneously creating a post-modern network of underground urban infrastructure and climate-controlled public spaces. The plan for Berlin begins by illustrating the very small differences in figure/ground between Berlin 1901 and Berlin 2001; their conclusion is that little is likely to occur, or need occur, by 2101. The Shanghai plan attempts to find alternate and multiple functions for the 2500-year old landforms - the weis – that still define the landscape in this low-lying region. The weis are connected pond-like infrastructures created by farmers for aquaculture, rice paddy farming, irrigation and flood control. The Shanghai design restores the historical landscape by adapting the wei to different modern uses, and at the same time retaining its ancient functions as a system for managing energy and material cycles.

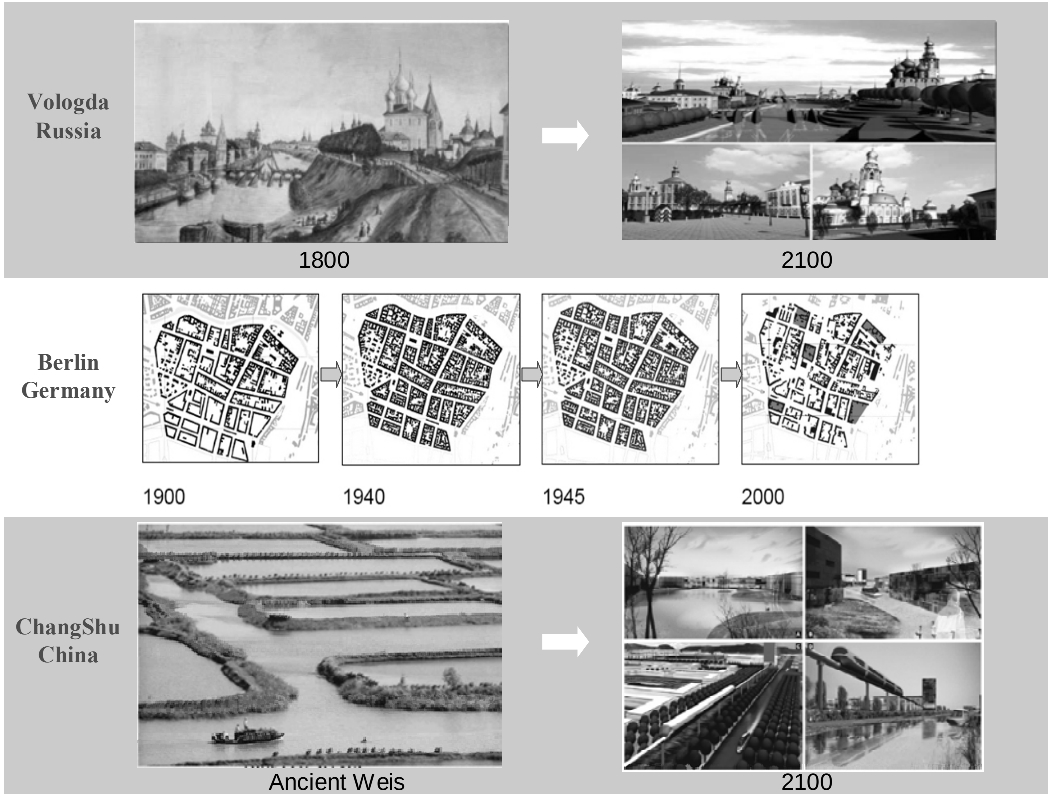


Figure 77 Long-term futures tend to be rooted in patterns taken from the long-term past

The plan for Goa, India returns the urban form and systems to the scale and locations of the self-governing Portuguese villages – communidads – of the 16th century (Figure 78). Each village is distinct and conforms to the local ecology, and is at the same time tied together into an urban system by means of modern transportation and communications. Their design concept is to restore the vitality of these original settlements over the next 100 years, including their rural surrounds, while simultaneously returning the nearby megacity of Mumbai to a smaller footprint and to its traditional functions of education, spirituality, celebration and healing.

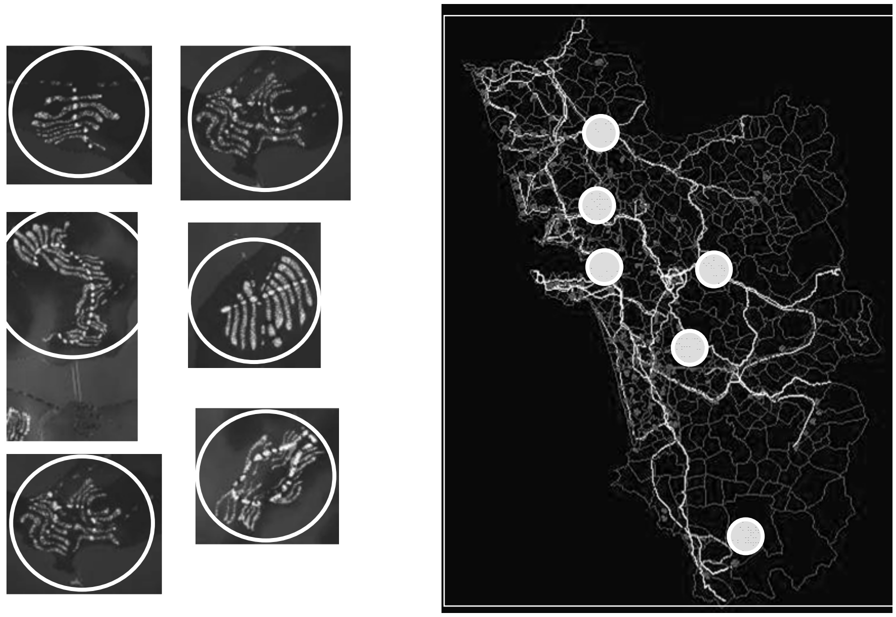


Figure 78 Long-term design for Goa conforms both to local environmental constraints and to the original layout of the Portuguese communidads

All of these sustainable system designs were intended to present pathways connecting present conditions to a 100-year vision. The 100-year horizon is sufficiently far away to permit an almost complete transformation of infrastructure and lifestyles, should that be desired. It is unlikely that the design exercise would change should the 100-year horizon be changed to 200 or 300-years. The 100-year date thus becomes a convenient technique for extending the present into the far future, and integrating utopian planning with modern urban design.

One of the more challenging and creative elements of such long-term design horizons is the choice of method for staging transitions. A staged transition requires that long-term visions and designs be staged over time as part of an evolutionary process, and then communicated as part of a credible storyline. Staging the design can help to rationalise what might seem, on first appearance, as impossible. It can also help to reveal a rational sequence and an acceptable pace of change – similar to critical path planning and strategic business models.

No obvious method exists for staging long-term urban designs, and thus each design team invented its own approach. Russia segmented the century into four equal 25-year periods, showing a progression in design at each stage. The USA team segmented the century into roughly three equal periods: 2036; 2070; 2100, and focused primarily on the first period. China presented their transition in two stages: 2050 and 2100. Japan (Mishima) described a continuous process or healing (urban acupressure) for the city, and then visualised the healing stages in four periods: 2030; 2050, 2070 and 2100. Japan (Tokyo) divided the design into three equal phases: 2033; 2066 and 2100. India used a detailed chronology of change for the first 30 years, and then simply showed a non-dimensional progression. Germany used few dates, and instead described a smooth transition over the 100 years. Argentina organised the transition into three very distinct phases: 2016 (Recovery); 2044 (Integration) and 2100 (Quality).

A lack of experience with long-term scenario development may be one reason for such diverse staging methods. Few professionals have given much thought to how infrastructure and lifestyles may evolve over the century, or to the 'S' curves that define the transition periods for so many technological and natural processes. Another explanation is the very large differences in rates of change in urban systems, as discussed earlier in terms of time rings. Depending upon the priorities and background of the team, the length of transition periods will naturally differ. Both the US and India had teams with strong backgrounds in new technology, and both emphasised the chronology of transitions over the next 30 years – an suitable event horizon for technological change, as explained earlier in this thesis. Beyond this horizon technology begins to look like 'magic' in the words of the Indian team, and thus both teams avoided detailed design.

Another factor is the rate of urban change and the perceived level of urgency. Buenos Aires, with a growing population and an economy in crises is more justified in emphasising alternative approaches over the next decade; Berlin on the other hand can afford to be more conservative and incremental. China is looking at a major change in population dynamics in 50 years time and this presents a natural milestone for urban design in a country being transformed by urbanization; Russia on the other hand, has a declining population, and the choice of milestones is more a question of how quickly a city can be physically reconstructed.

One observation that can be made from viewing this first set of long-term designs is that staging is a very effective heuristic for guiding short-term investments. The stages can be illustrated in sequence, like a comic book, and then used to create a political rationale for difficult short-term design decisions. The benefits of staging rapidly diminish past one or two stages. Subdividing the period from 30 to 100 years may be worthwhile as a communications tool, but such divisions are largely based upon interpolations rather than modeling. A 70-year scenario looks a lot like a 100-year scenario, in most respects. Only with the slowest moving systems, such as land use and ecological functions (the Nature ring), is it likely to be worthwhile to consider staging management strategies past 30 years.

Alternative tools for staging transitions are presented later in this thesis. However whatever methods are used it is clear that urban design scenarios become part of a political process. They are narratives that must be communicated to many players and thus one key criteria for choosing a method for scenario development is whether it helps to 'tell a good story'. Is the transition path something that participants need or want to hear? Does it help to convey key messages and support intended outcomes?

9.1.2 Advanced Scenario Planning

In *CitiesPLUS* the bi-directional time scale was cross-referenced to a second scale, indicating the level of control or influence for designers. The bi-directional time scale becomes an x-axis, and the level of control or influence becomes the y-axis. Time rings can be superimposed on the scales, creating a segmented scatter graph. The net result is a heuristic that appears to make scenario-planning both more versatile and more coherent for interdisciplinary design teams. The time variable allows the scenario planning or modeling to move easily from past to future, and from short to long-term. The control variable helps to separate those scenarios that have been – or will be – amenable to design decisions and those that are external to the design process. The two scales form a PLUS scenario wheel or 'timing map', that can be used for scenario development (Figure 79).

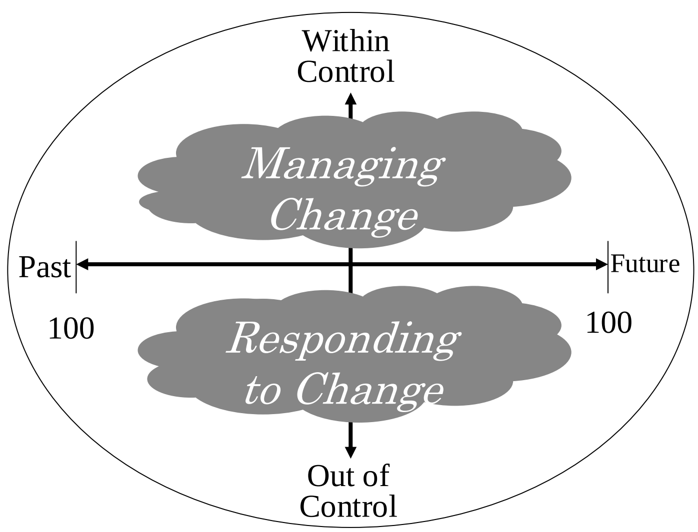


Figure 79 A Segregated 'Scenario Wheel' integrates rings of time with levels of control or influence

The upper two quadrants of the timing map fall largely within the scope of what a design team is capable of creating. From a long-term perspective, this is the area for pro-action: exploring how to direct and manage change. The lower two quadrants are largely outside the influence of designers, and consequently include the impact of external forces that transform cities. This is the area for re-action: exploring how to identify and respond to change.

During the *CitiesPLUS* case study, scenarios proved problematic for three reasons. The large number of sub teams, each with their professional bias, meant that confusion existed around the intended function of scenarios. Professions with a business orientation – economists, lawyers, and executives – are used to the vagaries of the marketplace, and tend to view scenarios as ‘possible futures’ in which they must survive. This was the purpose of the original scenarios developed by Pierre Wack for Shell. However when an entire community becomes involved in a long-term design exercise, quite a few factors fall within the purview of the players, and are amenable to control or influence. From this perspective the backcasting scenarios are crucial, especially when attempting to align multiple system designs, while satisfying constraints and targets. Thus the focus for scenarios in the *CitiesPLUS* IDP tended to alternate between preparing for the desired future, and managing multiple plausible futures.

Secondly, the tools for scenario development vary depending upon the time scale. The shorter the time horizon, the more variables that have known quantities, and the more effective become models that predict performance or quantify risk. As time horizons are extended, the scenarios become less quantified and more exploratory - providing order-of-magnitude insights on the relative impacts of different strategies under conditions of deep uncertainty.

Thirdly, scenarios are not confined to any particular stage of design work, but instead play multiple roles. The same scenario can grow with time, as the design team becomes more knowledgeable and decisions accumulate. At the Scoping layer, scenarios are part of understanding current conditions, and therefore are centred on how the present is most likely to unfold – the ‘Business As Usual’ scenario. At the Envisioning layer the scenarios are centred on the future, and describe how conditions are different from today. At the Exploring layer, scenarios are focused on the transitions from present to future, and on the relative merits of one pathway to another. At the Implementing layer scenarios can be designed to interact, with multiple design solutions competing in a number of very different worlds or ‘futures’.

For all these reasons, the PLUS approach to scenario planning required a more nuanced approach in which scenarios could be used for different functions at each level of the framework and at different time periods. Figure 80 shows how the timing map clarifies the potential functions by quadrant. Even with the timing map as a guide, it proved to be a challenge to orchestrate research and design and to take a balanced and integrated approach to use of scenario modelling.

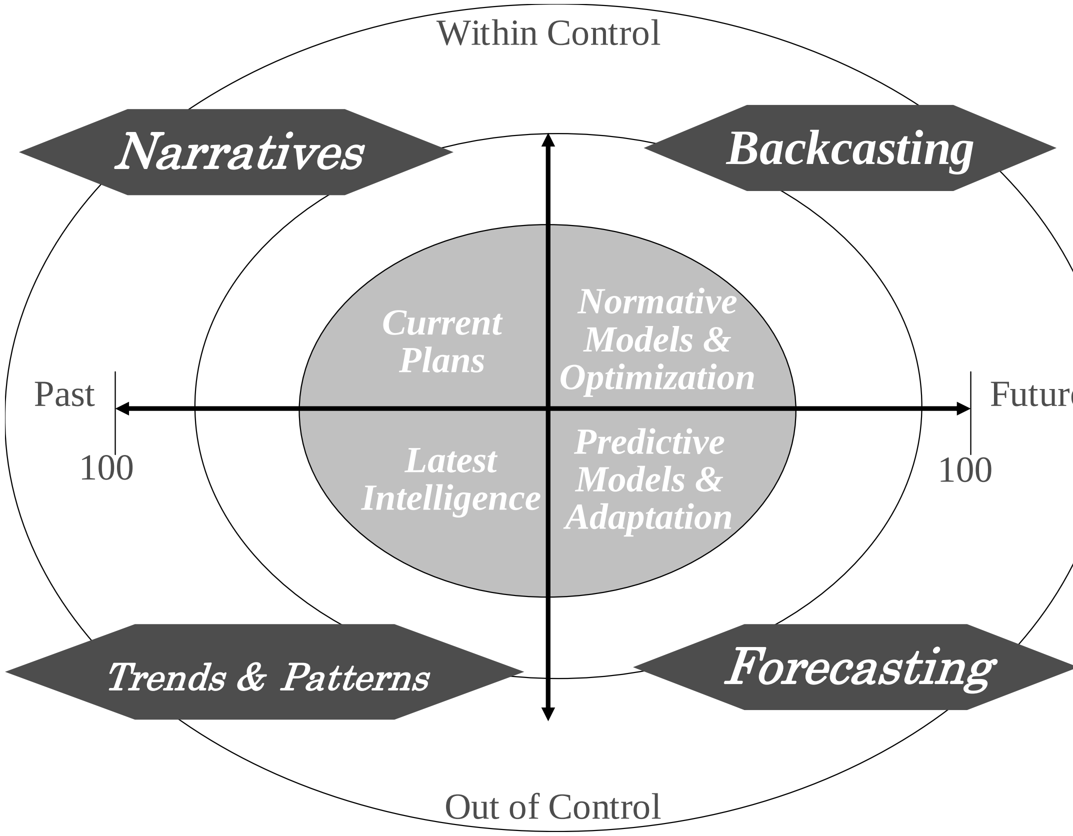


Figure 80 Scenario modeling tools can serve different functions depending upon their location on the Scenario Wheel

Within short-term time horizons, historical narratives help to define future scenarios, by defining the types of planning commitments already in place, and their influence. Such explorations help to communicate the 'Business As Usual' (BAU) scenario. BAU is not a frozen present, but rather a fruition of many recent decisions and initiatives. The term BAU is perhaps misleading precisely because it implies a continuation of existing conditions, rather than the execution of existing plans.[37]

Looking back in time over the long-term provides an opportunity to explore how choices influence consequences. It is these longer-term narratives that offer insight about the extent to which cities have power to control their fate. In *CitiesPLUS* repeated use was made of a narrative tool called "Choices and Consequences" which was researched and assembled for SRI by GVRD. The objective of the narrative was to help cities understand how

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[37] An alternative description for BAU might be the 'Do-little' scenario, from a conversation with John Robinson, University of British Columbia

significant benefits in quality of life and state of environment were achieved primarily as a consequence of pro-active planning and decision-making. The presentation uses historical images to illustrate stories about how Vancouver rejected the North American model of excluding residential from the Central Business District and in so doing helped to create a safe, livable downtown; how the city acquired Stanley Park – the largest urban park in the world; how the city stopped the Chinatown expressway and became the only North American city without freeway access to the core; how the region created a permanent multi-functional greenway, incorporating the provincial Agricultural Land Reserve, and so doing created the first long-term urban containment boundary in North America.

These types of choices contributed to an urban design that is significantly different than others in Canada and USA. Greater Vancouver uses approximately half the land area per person than nearby American cites like Seattle.[38] Unlike Toronto, Portland and most other water front cities it does not need to constantly struggle with how to remove freeways separating residents from the shoreline. It has retained a vibrant urban core, now judged to be the most densely populated, walkable and livable urban centre in North America. Of course Vancouver has its dark side too. The point is that history provides myriad opportunities for reinforcing any part of the human story. The choice of what stories or precedents to build upon may be a key part of the design process. Many of the individuals who were responsible for the stories mentioned above were also involved in the *CitiesPLUS* teams. This allowed the long-term plan to build upon such lessons as a regional equivalent to the technique of appreciative inquiry. These and many other narratives became part of the '*Seeds of Sustainability'* reports. Thus they share an empowering function: to emphasise how change can be managed for substantial gain, how the pace of change can be surprisingly rapid, and how strong local visions can overcome conventional thinking and short-term interests.

In the short-term future it is also possible to use scenarios for urban design. The important distinction at this scale is between scenarios, on one hand, and the evaluation of specific measures or best practices on the other. Scenarios, as described in Chapter 4, should be a rational combination of policies and programs that reflect one distinct approach or strategy to achieving broader goals, or that explore changes in fundamental assumptions about future events. Thus scenarios do not include any of the benefit/cost assessments or feasibility studies employed as part of standard design practice. The real value of scenarios is that they promote out-of-the-

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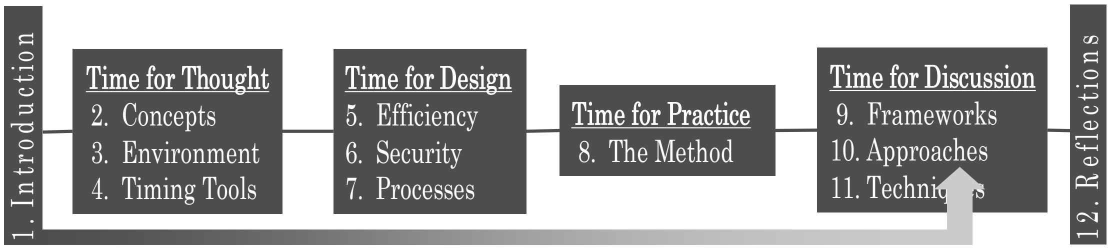
[38] Sightline Institute Score Card on Sprawl: see http://www.sightline.org/research/sprawl/res_pubs (accessed April 2006)

box thinking. In the domain of urban design the differences between broad storylines and design strategies can become blurred. For example, one approach to accommodating growth and achieving more sustainable resource use might be to introduce new 'green' neighbourhoods. Another might be to encourage infill, and to renovate and upgrade existing dwellings. The evaluation of such scenarios may require a degree of modeling, and optimization.

Forecasting and backcasting scenarios are compliments, and yet it proved difficult to integrate the two approaches. Experts in external forces are often unfamiliar with remedial and adaptive strategies, and an integrated approach is required. In the next chapter of this thesis new tools are proposed for such an integrated approach. Integrated long-term scenarios also compliment the short-term scenario planning. Problems that are intractable in 2 or 5 year designs become easy to resolve in a 35-year scenario.

One challenge in developing scenarios is the unavoidable conflict between need for more detailed, integrated and sophisticated technical design on one hand, the need for a larger group of decision-makers, with more public input and collaborative decision-making on the other.

10 How did Time Concepts affect Team Structure, Composition and Approach?



10.1 Categorizing the Urban Systems

The number of sub-systems, and their categorization, is frequently a source of debate, and proved to be a very difficult part of Scoping the *CitiesPLUS* research and team composition. As Hodge points out, even a standard physical plan for a community suffers from categorization problems. A common division might be: residential, commercial, industrial, roads, and public. "There are several inconsistencies in such a list: the categories 'residential, 'commercial', and industrial' specify the function of a piece of land while 'public' denotes ownership and 'roads' refers to a facility. And within categories there is reference both to facilities (such as 'school' and 'offices') and to functions (such as 'retail and recreation'). The industrial category on the other hand, distinguishes types of activities between firms. Our ability to understand the physical environment of communities is hindered by such classifications." [HODGE 98]

Extended time horizons increase opportunities for designing the urban system as an integrated whole, and this further complicates categorization. Perhaps nothing should be 'fixed' or isolated in the scope if the desired outcome is an integrated solution. On the other hand, bundling different systems together can increase the complexity of systems that are already difficult to model and design. The more complex elements within the bundle are thus more likely to be ignored, or treated superficially.

10.1.1 The Kaleidoscopic Approach

In the *CitiesPLUS* design it was felt important to honour the past experience of participants, and to emphasise a successful collaborative process rather than an ideal structure. Thus the categorization of systems was not based on theory about system design (elements, functions, dynamic relationships). Nor was any attempt made to push the experts together into more integrated or combined groups. Rather the principle was to simply start with where people are at, using the terms and divisions and relationships already embodied in the participating organizations. Then the challenge was to move towards a more elegant and integrated structure at a pace acceptable to participants. It is impossible to know whether an alternative approach might have worked better. Even the decision to reflect traditional divisions left many questions unanswered: How fine a division? How broad a scope? How and when to align the work of sub-teams and explore integrated design solutions?

Many criteria needed to be addressed as part of system categorization. The number of sub-systems must be limited to conform to the time available, the budget and the human resources. Every new sub-system implies some degree of additional effort to acquire foundation knowledge, visions, goals, targets and strategies. The categorization of sub-systems also needed to reflect the scope of the exercise, the capacity of the analytical models and tools, and the priorities and opportunities for influencing performance of systems. As the work progressed and details resolved, the division of sub-systems needed to be further refined, and the same questions about categorization reappeared.

At the start of the process, a variety of options were considered for how to 'cut the cake' of an urban region, none of which seemed adequate on its own. One option was to focus on the cross-cutting system flows such as energy, water, materials, people, and nature. This approach is attractive because it complements the simplified environmental accounting systems described in Chapter 4. However the sustainability paradigm must also embrace the economic, social and cultural aspects of urban regions. It is almost impossible to achieve integration and synergy between these spheres if the relevant urban systems are not included to some degree in the design scope. Thus a more synoptic or holistic scope seems unavoidable when the intention is to create or refine a long-term sustainable design. Maintaining balance between the spheres may be more important than the precise definition of specific systems within spheres.

From the economic perspective a traditional categorization might be to reflect the land use typology: residential, commercial, industrial, and institutional. Alternatively the systems can be divided more finely into the categories used for national accounting systems and Input/Output models: construction, manufacturing, services, and so on. A third approach is to focus on the end-use demands that drive the investment into urban systems, including shelter, food, culture, recreation, education, and health. A final approach is to simply categorize systems in accordance with the divisions already used to institutionalise urban policy, urban planning and system design. For example, most urban regions engage in long-range planning and design for transportation, housing, land use, population, sewer and water, electricity, natural gas, and waste management.

Any single approach fails to capture the nuances of others, while any combination of approaches invariably suffers from overlap and redundancy. Take for example energy and transportation. Both systems have institutions, facilities, services, plans and so on, and deserve special attention as a distinct system for urban design. And yet transportation accounts for about 50% of typical urban energy uses. It is impossible to address one without addressing the other. In the long run, a well managed region may need both an energy system design and a transportation system design, each functioning alone, and each as a subset of the other. Thus the design of both energy and transportation systems may only need to be aligned or nested, rather than merged.

The method applied in *CitiesPLUS* was described as a System Kaleidoscope. Many teams are formed around separate elements of the urban whole, and then joined together from different perspectives to form variations. The philosophy was to "let redundancy reign". At some point, with enough subsystems addressed in the design, redundancy helps to fill any remaining gaps, and compensate for missing systems or a less-than-perfect categorization. Redundancy becomes a friend.

The *CitiesPLUS* Kaleidoscope contained 18 separate sub-system teams, distributed across the rings of time, as shown in Figure 81. Situating the sub-systems on time rings helps to balance the short-term and long-term, and the spheres of sustainability. It also helps to guide alignment and integration processes as part of a unified or 'One-System Approach' discussed later in this chapter.

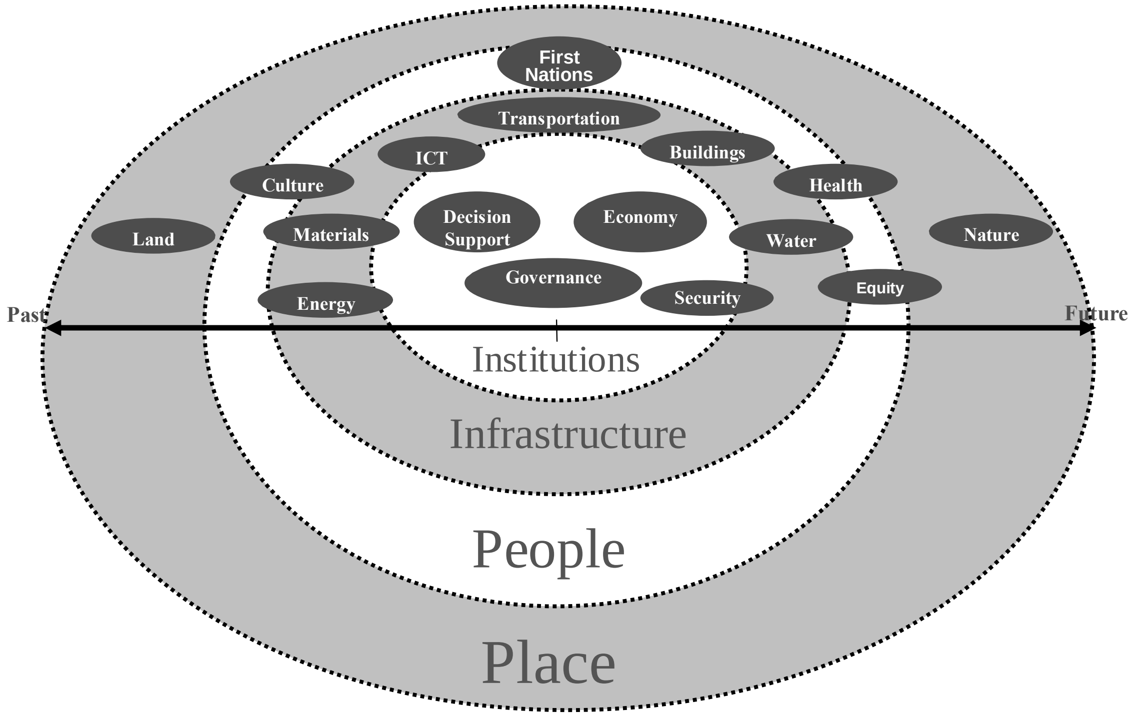


Figure 81 Selected sub-systems for urban design in *CitiesPLUS*, balanced across the rings of time and spheres of sustainability

Although many of the subsystems in *CitiesPLUS* were obvious candidates for sustainable urban design, others were uncommon, and emerged only after a process of discussion and investigation. The value of unusual categories is surprising, and warrants discussion. For example, 'First Nations' refers to the racially defined communities of aboriginal peoples living within Greater Vancouver. This is not a typical category of 'urban system' and might normally be ignored altogether in a design exercise, or addressed as part of social systems such as Culture or Governance. However Greater Vancouver is unusual in containing 9 urban reserves, each of which functions as an independent community (although most share parts of the regional infrastructure systems). The reserves are self governed, with distinctive cultures, housing and histories. Greater Vancouver also contains over 50,000 urban aboriginals, from over 50 tribes.

The reserves have remnants of the ancient systems which sustained the Coast Salish peoples for thousands of years. These systems have implications for the long-term, especially if streams and shorelines are to continue ecological functions and provide livelihood and food, and opportunities for traditional lifestyles, cultural events, and land-based views of time. The 100-year plan offered a unique opportunity to cautiously rise above the current struggles for power and reconciliation that dominate political discussions with these reserve communities. Through meetings with Chiefs and elders from the reserves it became possible to hear stories recounted from past generations. The First Nations researchers participating in the Sub-team referred to these as 'story-scapes'. They are stories about specific locations, and how recent history has altered important aspects of land and water, the relationships between peoples, and the role of sacred sites. Such local knowledge became an essential component of the transdisciplinary research, and helps to explain the importance later given in *CitiesPLUS* designs to recreating the salmon spawning streams, to designing neighbourhoods around the stream layout, and to restoring a naturalised foreshore in locations close to reserves. The First Nations reserves were the only participants in *CitiesPLUS* who viewed themselves as inseparable from the place, with an absolute certainty that their families will continue to reside within the region for the next 100 years. The urban aboriginals, on the other hand, provided detailed research and some of the most specific end-state goals on how cultural identities and alternative lifestyles might be incorporated into a long term vision for Greater Vancouver. [www.citiesPLUS.ca Aboriginal Foundation Paper]

Other urban sub-systems also provided surprising results and in retrospect it is difficult to identify which systems might be considered optional. The ICT team was a surprise since it was initially seen as a peripheral system that could safely be ignored. As documented in their Foundation Paper, the role of ICT is rarely or never considered at the concept stage in urban design, and instead the engineers are expected to install antennae and re-configure control information systems after the fact. Yet a very enthusiastic *CitiesPLUS* ICT team provided considerable insight into the benefits of a more integrated approach. [*Information and Communications Technology Foundation Paper*, 2003, www.citiesPLUS.ca] They explored the potential for using the ICT sub-system to enhance the information flows that contribute to the goals of all other urban systems – an opportunity that has been explored more recently by EU researchers [CURWELL].

These examples serve to underline the value of striving for a very broad scope when categorizing systems and establishing an integrated design team. However as scope broadens, so too do time requirements, financial costs and complexity. Ultimately the choice of systems and issues needs to be guided by both practical considerations and the political process. The most important element of the Kaleidoscopic Approach is to seek a balance between time rings and spheres of sustainability, and to integrate all selected systems into the base of the SEEIM framework (Figure 82), so that they can be linked together at each stage of planning and design.

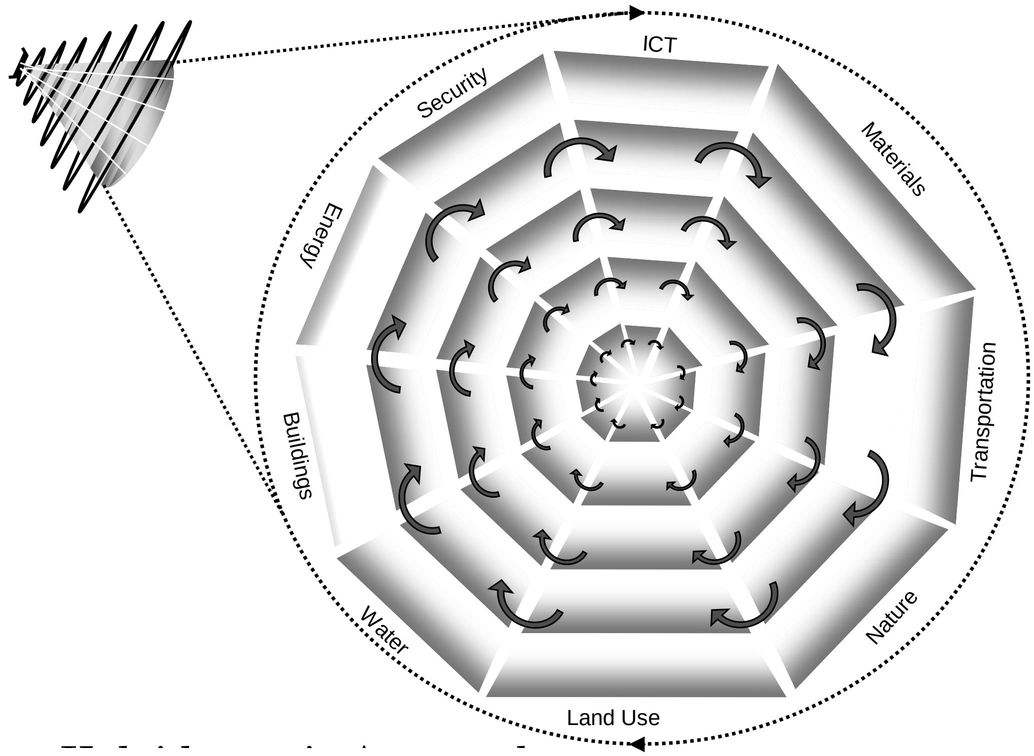


Figure 82 A Kaleidoscopic approach forms the base of the framework, and links each selected system at each layer

10.2 How does the Design Team Work Together?

One of the challenges for urban system design is structuring a design team that incorporates the combination of skills, and the range of influence, needed for integrated design solutions. At the scale of individual buildings, a design team can achieve many innovative solutions without addressing the larger issues of fiscal policy, land use zoning, health and safety regulations and so on. However when spatial and temporal scales are extended, a team may encounter many regulatory and non regulatory barriers that are embodied in the administrative and institutional rings.

Integrated systems design may require the ability to not only integrate systems elements and flows, but also to reform the institutional policies and structures. For example health policies commonly prevent the use of reclaimed water for irrigation and toilet flushing; fire safety policies prevent the downsizing of streets and infill; electrical utility regulations prevent two-way metering and credit for on-site generation. The prevalence of such administrative barriers may be a more significant challenge than technical design solutions.

In *CitiesPLUS* the most critical policy barriers were financial. Firstly, capital investment approvals tend to ignore potential returns from reduced operational budgets, and thus prevent long-term investments in more durable and efficient systems. Secondly, fiscal structures tend to force developers to pay a fixed tax, fee or charge as payment for centralised systems and remote facilities, even in cases where their on-site design innovations reduce or eliminate the need. Thirdly the separate administrative structures (silos) and narrow mandates for each type of urban system prevent transfers of resources for net gain; – for example transferring money from the highway budget in order to create pedestrian friendly, mixed use communities that reduce the demand for road space and road repair.

Financial barriers of this type are well documented, and are worth mentioning here only because they emphasise how long-term urban system design is really impossible without policy reforms and institutional involvement. For this reason the collaborative model adopted for *CitiesPLUS* became increasingly important as an approach for structuring the design team. Most of the other SUSD teams involved included local government and NGOs as advisors, and in the US special effort was made to bring together the San Diego and Tijuana in a cross-border collaborative. However only in Canada was a major effort made to engage all sectors of the community in the design process, an effort which entailed major investment in cost and time. The result can be described as a new process tool that brings together Integrated Design and Collaborative Decision-making (IDCD).

10.2.1 Integrated Design and Collaborative Decision-making (IDCD)

As mentioned in Chapter 7, collaboration was a central feature of *CitiesPLUS* from the initial project design onwards. Although local government was a key participant from the outset, the regional and long-term scale meant that many of the systems that should be included in the scope of design were not exclusive to government operations or services. Figure 83 shows how the scope of systems can be illustrated using three tiers of government participation. At the core, the local government is directly managing their corporate operations, including for example the operation of government offices, transportation fleets, and purchasing of supplies. At the next tier the local government is a municipal service provider, responding to needs for water, waste management, transit and so on. At the third tier, is just one of many players that influence the regional systems – systems that are very influential elements of the whole urban system, and that may benefit from integration in design. While local government can play an important leadership role in addressing the third tier, and attempt to accomplish 'triple tier planning' must engage many other players in a partnership process. Hence the necessity for collaboration.

Figure 83 'Triple-tier planning' requires local government participate in a collaborative approach in order to integrate the many regional systems in long-term solutions

Initially the 'PLUS' in *CitiesPLUS* was an acronym for **P**lanning for **L**ong-term **U**rban **S**ustainability. PLUS also referred to the potential for added value from extended time horizons. However as the design process evolved, PLUS also became a symbol for a more 'balanced approach' to design and decision-making. The four quadrants in the plus character '+' reinforce the structure of the collaborative process. Figure 84 shows how the PLUS quadrants symbolise collaboration between four sectors: government, academia, civil and private.

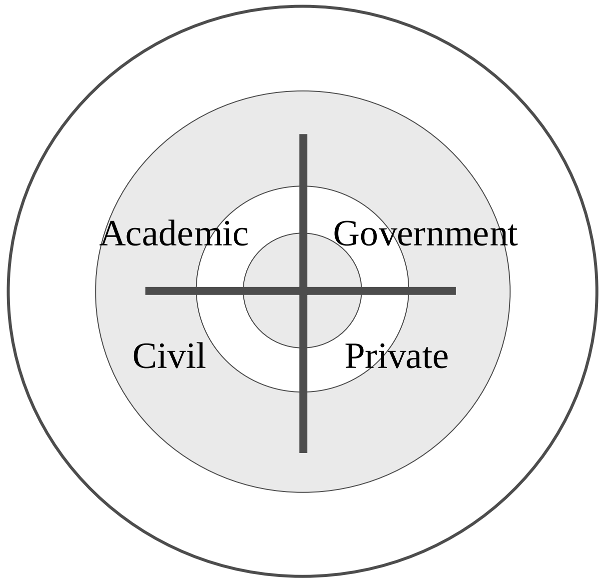


Figure 84 A PLUS Collaborative seeks representation from four sectors and from the different time rings within each sector

All four of these PLUS sectors were represented in each foundation team, and in each workshop and charrette. Based upon the subjective experience of leading these groups, the four-part recipe was especially important for effective visioning and for implementation. Involving regional government senior planners helped to provide the resources and networks needed to address the entire region. Involving advocates and academics helped to temper the risk averse and short-term perspectives of government employees. Involving senior statesmen in the core team, as chair and vice chair, helped to create the trust and good will needed for such broad collaboration.

Collaborative models appear to work well with extended time horizons. In fact the complimentary nature of long-term design and collaborative decision-making was one of the most surprising results cited in the conclusions of the *CitiesPLUS* submission. By extending time horizons, a refreshingly positive view of the future emerged. Discussions became more satisfying, and participants became more willing to stay engaged in the process. A more creative discussion can occur under such conditions since the time horizons for Envisioning and Exploring exceed the participants' term of office or lifetime. Protecting individual wealth, privilege and power is less of an issue, and emphasis is given to clarifying visions and defining planning principles. A shared purpose emerges around providing a heritage for children, and for generations to come. A presentation of the 100-year plan to Vancouver's social planning council provoked one of the councillors to remark that the plan was especially significant because it offered the city a truly positive view of the future – something they have been missing for many years even in a city as blessed as Vancouver.[39]

CitiesPLUS thus evolved to combine Integrated Design with Collaborative Decision-making (IDCD), as illustrated in Figure 85. The PLUS symbol divides the time rings into the four sectors. The rings indicate not only the principle stage in discussions where groups have significant responsibility and input, and thus the scatter diagram coveys sector, role and timing. Closest to the centre are the four design team leaders, each from a different quadrant, and each responsible for day to day decisions. These leaders are surrounded by a core team of 8 to 10 experts who are responsible for detailed organisation and design. Surrounding the Core team is a Collaborative Board, addressing the issues of strategic direction, financing and accountability.

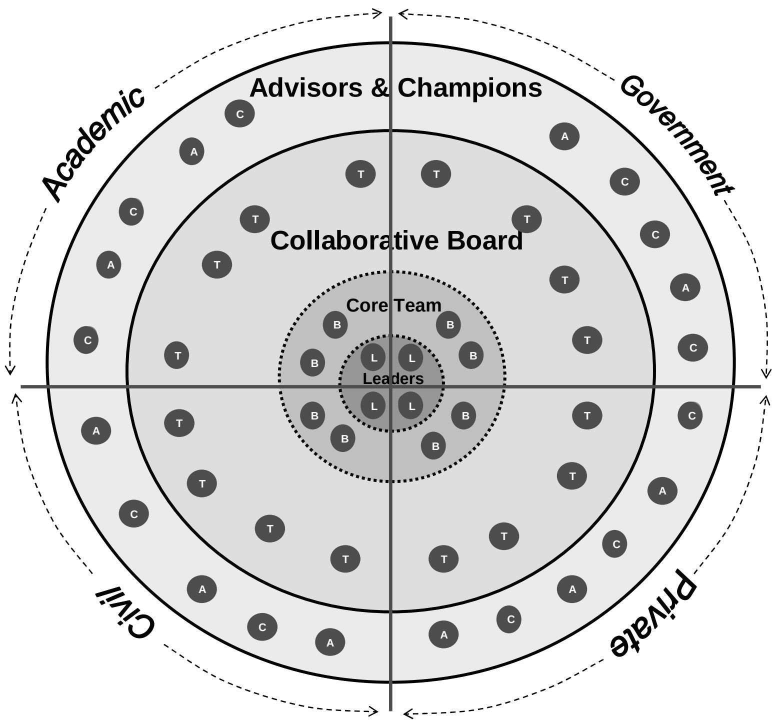


Figure 85 The PLUS Collaborative team is created by four rings of responsibility, each populated by four sectors

Outside the board lie Senior Advisors and Champions, who constitute the collaborative body – or regime, who provide regular advice and direction on elements of the design, and who participate in workshops and charrettes.

The Champions have the additional role of emissary for specific urban sub-systems; thus each Champion facilitates communications between the

[39] Feedback received during a presentation by Moffatt and Campbell to Vancouver Planning Commission, May 2003.

design team and a network of experts (sub-teams), as shown in Figure 86. The number of Champions and Sub-teams varies, in keeping with a Kaleidoscopic approach. The location of the sub-teams can be close to the advisors, or distant, depended upon their pace of change or lifetime within the large one-system perspective (the layers of longevity).

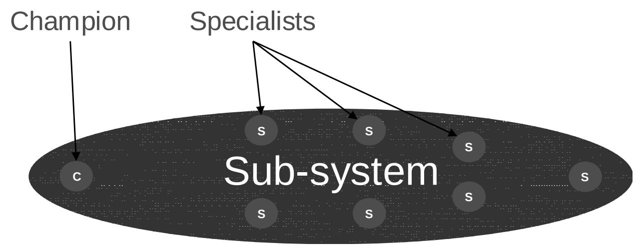


Figure 86 A network of specialists for one system is connected by the champion

The systems connect to the collaborative via their Champion (Figure 87), creating a structure that can be imagined as an inflorescence – i.e. a single flower composed of many flowers, functioning as a single entity. This is another way of describing the emergent property of transdisciplinarity within a collaborative and interdisciplinary team. In the words of David Rapport, writing in Transdisciplinarity: Recreating Integrated Knowledge, “to cope with real-world complexity requires a conceptual framework that builds bridges between isolated disciplines – transcends the boundaries of the ‘artefacts of scholarship’. “ [SOMERVILLE 2000]

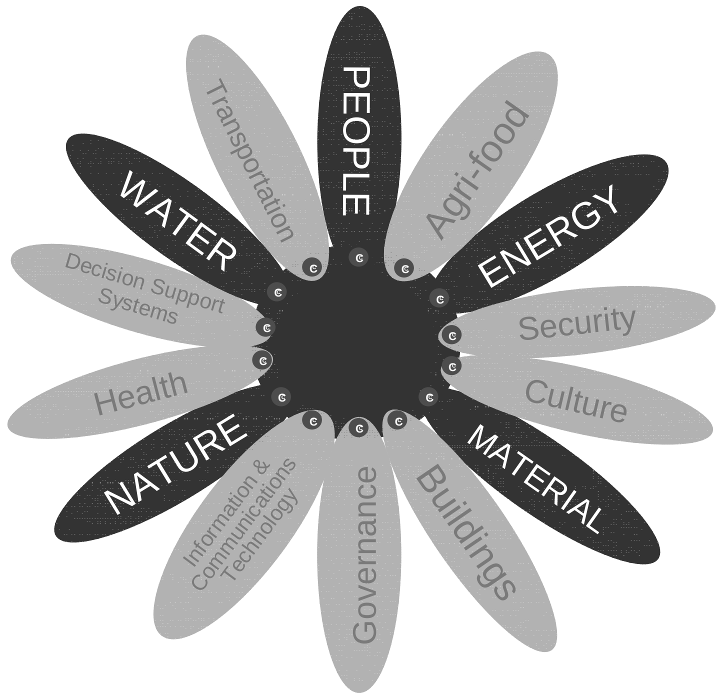


Figure 87 Champions link their systems into the collaborative structure, creating an 'inflorescence' that facilitates transdisciplinary research and design

The flower motif also provides a metaphor for how IDCD teams can be sustained through a resource base and integrated into a 'garden' or learning network. Figure 88 shows financial and human resources (nutrition) supplied by local sponsors and citizens, and further input of new ideas and tools shared between the teams (cross-fertilization).

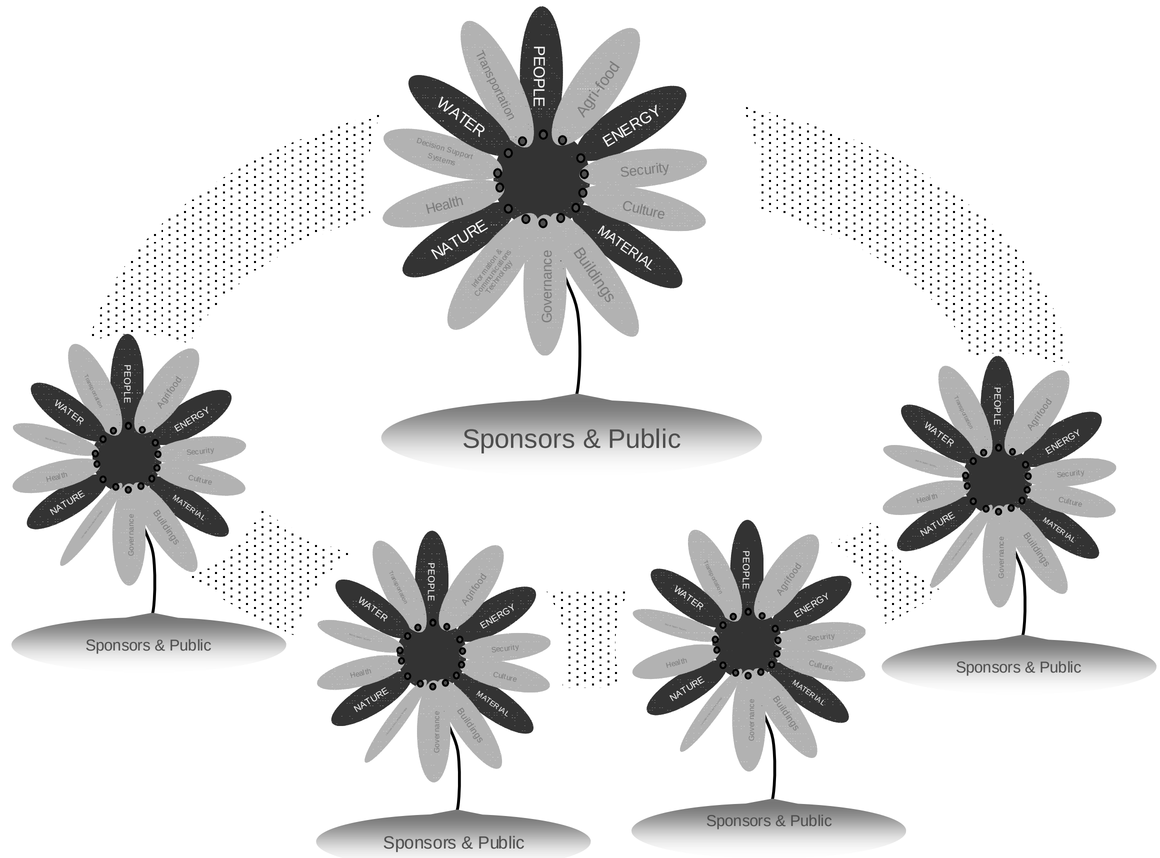


Figure 88 The PLUS Collaborative receives financial and human resources locally, and then shares skills and tools with other locations in a process analogous to cross-fertilization in a garden

It is difficult to conclude from a single case study whether such collaborative structures are a necessary element of a successful long-term urban design process. Experience with green building design suggests that the integrated design process is the single most important factor influencing a successful outcome. [CBIP] However at the scale of an urban region, the design process has much greater complexity, and comparisons are difficult. Brugmann, the founder of the ICLEI network, participated in *CitiesPLUS* as a member of the Governance sub-team, and argued that this type of 'urban regime' is necessary for effective governance and as a way to develop a culture of sustainability across all sectors: [BRUGMANN 2002] It is difficult to imagine another model for addressing utopian planning and design for such a diverse and complex range of urban systems.

The greatest flaw in the process of IDCD is the lack of seed capital and ongoing budget to sustain the process. Almost by definition the role of the collaborative is outside the mandate of any specific authority or funding body in an urban region. Even if all other ingredients are present, including a will to work together, the lack of financing mechanisms can paralyse the region. Other than a philanthropist – or a well-financed industry that adopts a long-term perspective like the International Gas Union – it appears likely that the collaborative approach to regional design is itself unsustainable.

10.3 The 'One-System' Approach

Within the context of traditional practice a design team can work in an iterative and rapid fashion across a wide variety of design choices at each stage in the process. Experience and intuition guide their work, as they move from the most determining factors like circulation and land use patterns to more specific issues such as critical infrastructure systems and the efficiency of built elements.

In *CitiesPLUS* the alignment of multiple systems pathways, and participation by a diverse group of non-design experts, suggested the need for a structured and rational approach to guiding design teams during the pathway development. The intent was to supplement the intuitive design process with a tool that could be used to orient the team and reinforce a systems perspective at the regional scale, when appropriate. It is also a way to cope with the complexity of analysing the huge array of possible strategies and actions for any pathway – energy, water, materials and so on. By adopting a systems-approach to modelling and scenario development, it may be possible to achieve more intelligent spatial, temporal design.

Since the approach is about systems thinking and integrated design, it is referred to as the One-System Approach. A report on the One-System Approach was prepared as a guide to thinking and design while developing pathways for *CitiesPLUS*. Later the report was later used to explain and illustrate the fundamentals of the design philosophy ["The One-System Approach" www.citiesPLUS.ca].

The One-Systems Approach organises design options into a rational sequence, beginning with those strategies most likely to achieve long-term, whole-system solutions, and ending with shorter-term and less interdependent choices. It also helps to coordinate the work at varying scales to optimise the synergies between scales, and the overall efficiency and resiliency at a systems level. The inclusion of both temporal and spatial scales makes the Systems Approach a potential timing tool for regional design.

The structure of the temporal scales and spatial scales is illustrated in Figure 89. The temporal scales are time rings. The spatial scales stretch from the parcel to the entire region, with intervening levels such as block, corridor, neighbourhood, and city. Within each scale the design is driven by a common set of visions, goals and targets, as outlined in the SEEIM design framework.

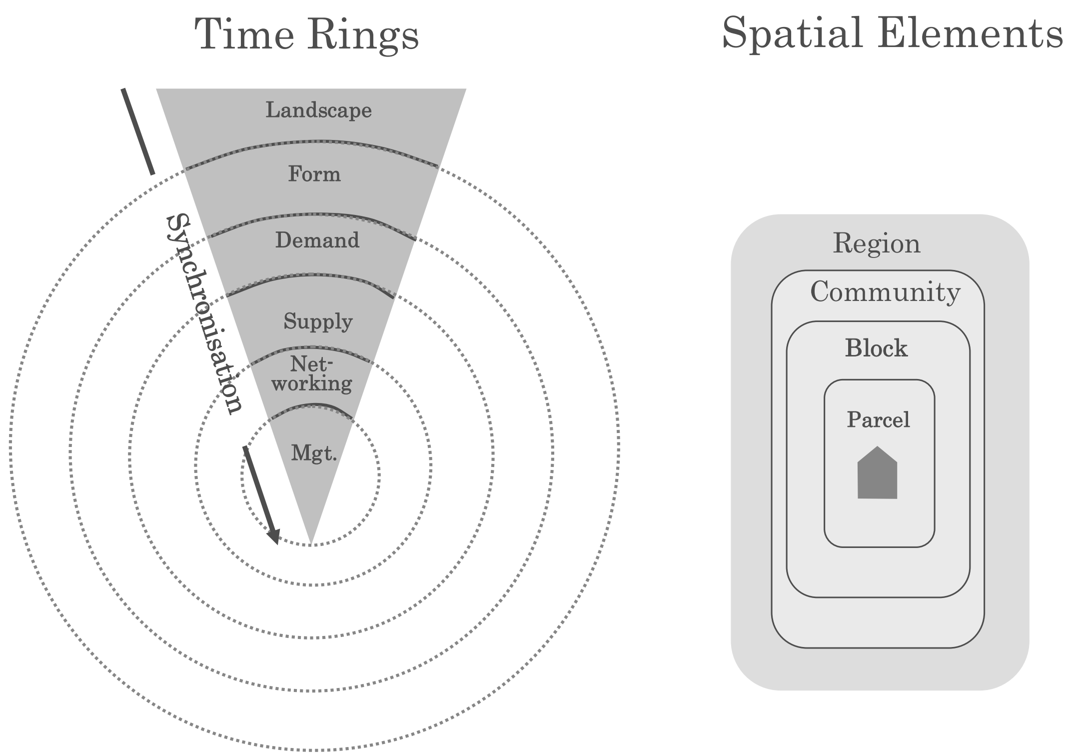


Figure 89 The challenge is to integrate nested scales for time and space in urban regional design

The One-System Approach organises the design process across the scales by using three operating principles: Synchronisation, Localisation and Synergisation.

10.3.1 Synchronisation

Synchronisation refers to the ordering of design strategies in accordance with the time rings, progressing from the slow-moving elements such as land and nature, on the outside rings, to the fast moving elements like management processes, on the inside ring. The outside ring is especially important, since it is here that consideration must be given to *Landscape* - the regeneration and protection of key environmental functions and the integration of the natural resources into a long-term landscape design. The sequence then progresses through *Form* – the integration of urban form with the physical metabolism; *Demand* – the aggressive reduction of demand through design of systems and components; *Supply* – the matching resource flow timing and quality to the requirements of the end use; *Networking* – the cascading and recycling of flows through nested intelligent networks (for electricity, thermal energy, water, people, materials and information); and *Management* – the operation and tuning of systems for least cost and continuous improvement and adaptation.

By moving from outside in, the traditional short-term, city-centric design paradigm is inverted. Elegant solutions are possible, by designed the structure in ways that maximise benefits for the system as a whole. For example the landscape and form strategies are given serious consideration early in the design process, allowing for interaction of morphology and physiology - similar to the Netzstadt Model. Local efficiency and demand reduction is considered prior to exploring supply options; why bother developing supplies and networks if demand has been eliminated. For example, district cooling makes no sense if the buildings can be designed to economically meet their own needs for cooling all year round.

10.3.2 Localisation

Spatial scales play a key role during the development of long-term pathways. Periodically design strategies at each physical scale are shared with other physical scales, in a joint exploration of options for integration and connectivity. The interaction of spatial scales is illustrated in Figure 90. Interaction is driven in two directions: from local to regional, where the driving principle is Localisation; and from regional to local, where the driving principle is Synergisation.

Localisation means that designers will attempt to achieve the goals and targets always at the most local scale possible. All that is passed on to the scale above are those services that cannot be successfully provided locally, due to technical, economic or practical reasons. Localisation can be considered as the opposite of the EU principle of subsidiarity. Rather than let decisions devolve to the most local level possible, it begins at the parcel, and places maximum responsibility on the most local design teams. It is they who first explore design options, and thus have the greatest freedom to innovate. Service requirements are then passed on, like a baton in a relay race, except that the baton gets much lighter at each stage until, at the regional level, there may be little or no need for infrastructure investments.

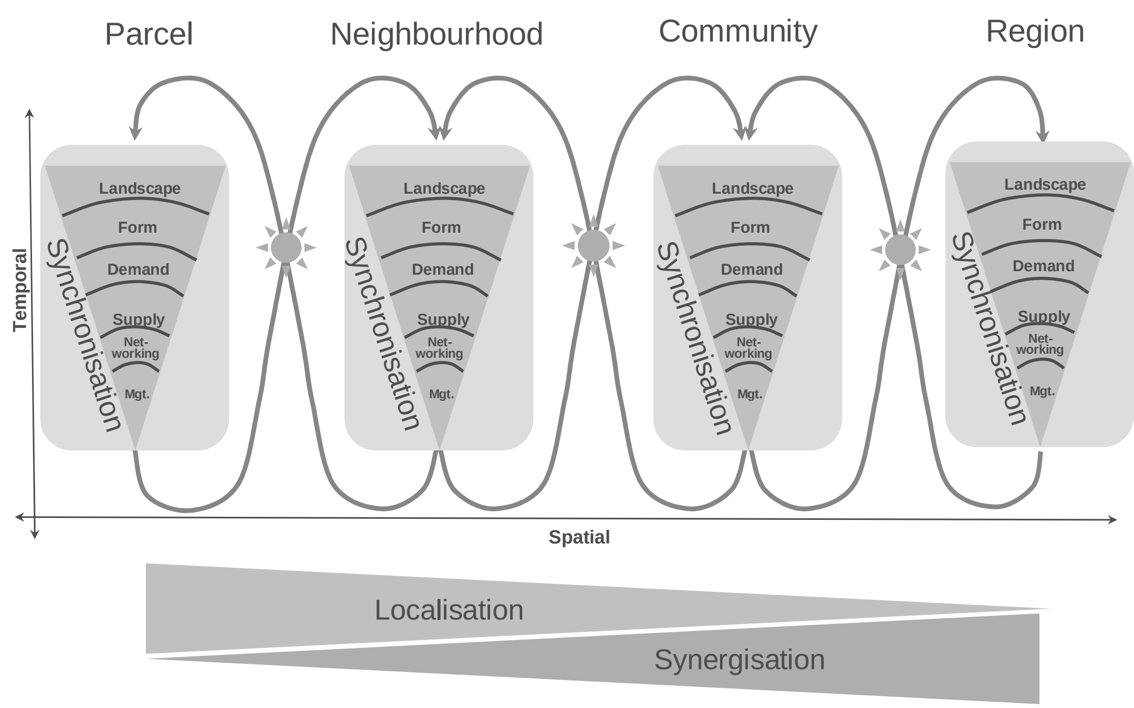


Figure 90 The One-System Approach synchronizes the time rings, localizes functions and achieves positive synergy at every spatial scale

10.3.3 Synergisation

Synergisation refers to the spatial interactions that are being driven in the opposite direction – from the region back to the parcel. It is these types of interactions that traditionally lead to struggle and political conflict around the recurring themes of independence vs. integration, or local government vs. centralised government, or private property rights vs. community planning. Synergisation is an attempt to clarify the roles of the macro scale entities, by emphasizing how they are essential to achieving synergies amongst all the other scales and elements. An appropriate metaphor is the symphonic orchestra, where the region serves in the role of conductor, helping the many parcels, blocks and neighbourhoods coordinate their efforts, transforming cacophony to music.

The region as conductor emphasises the enabling functions and the added value, rather than a centralist design model. Enabling activities can take very different forms. For example it can be helpful to provide information to the local designers regarding LCA, and specifically what technologies and resources are likely to complement the regional goals for sustainability. Information can be transferred in the form of training, certification, requests, recommendations, fee structures, incentives, pricing signals and continuous feedback systems.

Enabling can also occur by means of improved connectivity at the finer scales. Creating regional or sub-regional networks enable local design teams to share surpluses between neighbours, to market any excess resource, and to use the grid to temporarily store surpluses and thus match a limited quantity of supply to their demand load profiles. In theory at least, a combination of Localisation and Synergisation can produce highly self-reliant, efficient and diverse parcels that also achieve elegant solutions where the whole is much greater than the sum of the parts.

Example of One-System Design in Greater Vancouver

The *CitiesPLUS* design for Greater Vancouver proposes *Webs of Green and Ribbons of Blue*, as a catalyst strategy. The strategic thinking behind this strategy provides an example of the One-Systems Approach.

Synchronisation: The design begins with the landscape and ecological functions. The water catchment areas are fully protected and preserved pristine forests surrounding reservoirs in the mountains. The systems are entirely gravity fed as is currently the case. The streams are protected with riparian strips where no construction is allowed. The shorelines are naturalised in places where nursery habitat is required for herring and salmon and shell fish. The structure of the stream flows from ridges to shorelines divides the land area into super blocks into which are fitted the buildings and open space for residents – essential the grid of divide and streams comes to represent a new division of neighbourhoods. The flood plains are converted to temporary uses (e.g. exhibition grounds) instead of residential communities. Low-lying areas subject to flooding are converted to wetlands and recreation, adapting to sea level rise. The water demand is organised on the landscape to allow for a natural cascading and reuse of water, - beverage industries above, residential and commercial in the middle, brick making and machining below.

Localisation: At each location the run-off water is largely 'processed on site' through attenuation, and through infiltration and sub soil cooling and cleaning, or through reuse in irrigation, sewage treatment, water amenities, toilet flushing, heat pumps and back-up water storage, or aquifer recharge. Organic waste materials produced on-site is used to increase the water retention capacity of the soils, and thereby reduce the flow rates and the irrigation needs. The amount of technology dedicated to storing and treating water on-site depends upon the life cycle costs relative to other scale options, and also to the balance of water capacity to demand for the region. The design of the storm water system is integrated with the potable water and sewerage, and also with the building, landscape and transportation systems (Figures x).

Figure 91 The One-system approach: storm water management features simultaneously serve to reduce energy demand, enhance transportation options, reduce demands for treated water, create local amenities and facilitate waste water treatment.

Synergisation: The ribbons of blue move into and out of the built environment, with the individual parcels cooperating to regulate natural systems, and augment dry season flows. The water flows become a unifying element in the urban and natural landscape. The water is metered and priced in ways that reward designs that allow for conservation in dry periods, and that direct water to its best use, and that allow for reuse and recycling by neighbours. A systems map of water stocks and flows is web accessible and updated with real-time sensors. The natural watershed, water budget and water systems become a determining factor is defining the urban form, land use, land surface materials, types and amounts of vegetation at every scale. During storm events the combined city water run-off is similar to what would occur from a forest.

Example of One-System Design in Northern Netherlands

The Bridging to the Future workshops provided additional opportunities to explore the One-System Approach. An example is the SD charrette facilitated by the author for the Northern Netherlands team, for the purpose of developing a long-term urban region design[40]. [GROUNDS 05]

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[40] A region composed of three provinces: Groningen, Friesland and Dierdre.

The charrette took place over a full week and included 70 professionals, organised into five design teams. The regional team examined both energy and water systems from a 100-year perspective, and then created a 30-year pathway. From the long-term ecological perspective, the design challenge was to develop urban systems that conform to long-term constraints: the rising sea level, the 30-year remaining lifetime of the natural gas reserves, a shrinking population base.

Currently the region is probably the most designed water land environment at the regional scale in the world. (Figure 1) Fitting the region into the natural landscape required a major rethink, since 1000 years ago the whole area was underwater – part of the Rhine River delta, and a North Sea estuary. With the prospect of rising sea levels over the next century, it was necessary to determine if it still makes sense to maintain dykes, and pump all the Rhine River water up and into the North Sea. This entails very high costs, and creates problems with loss of wetlands and beaches, leaching of salt water back into the ground water table, pumping costs, drying out of the 'uplands' environment in the interior of the provinces and so on. Costs and vulnerabilities rise with time, and the eventual result of 'fighting natural forces' is expected to be a failure in the system, with consequent flooding of large areas of the region.

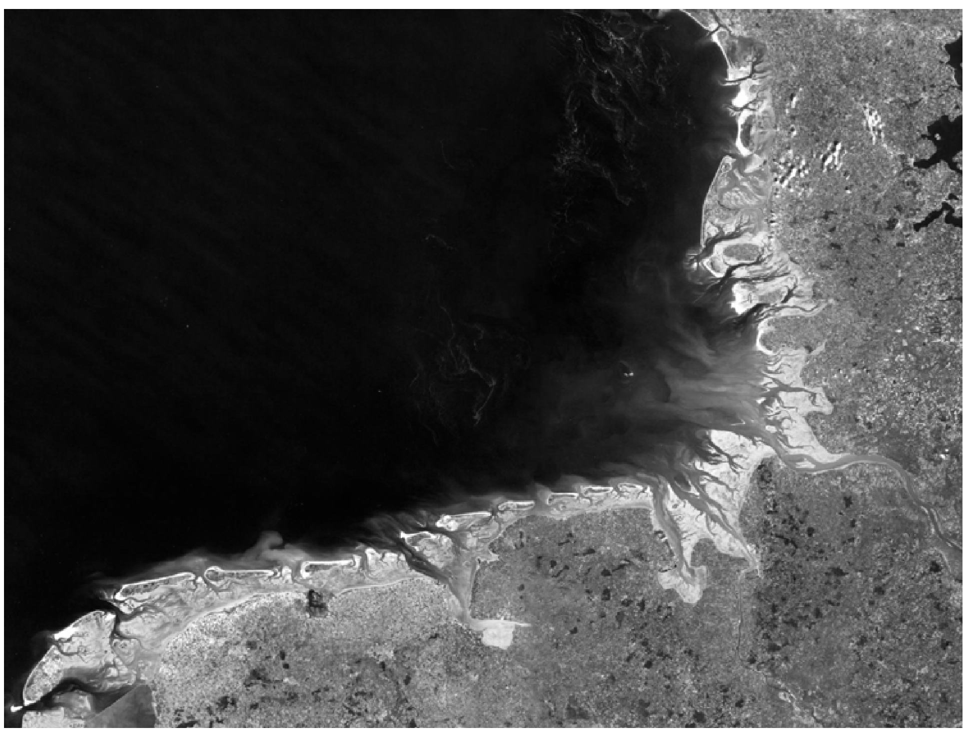

Figure 92 Northern Netherlands is a low-lying man-made environment that is extremely vulnerable to sea level rise and climate change

The solution proposed by the regional team was to explore selective sweet water flooding of parts of Friesland, the re-introduction of salt water estuaries along the Groningen coastline, and a more functional blue-ways transportation system, and protection of the upland catchment areas as biomass reserves. Figure 93 shows how this ecological design for the urban region emerged from an integrated approach that examined the energy potential on the landscape and the other relevant landscape features over the next 35 years.

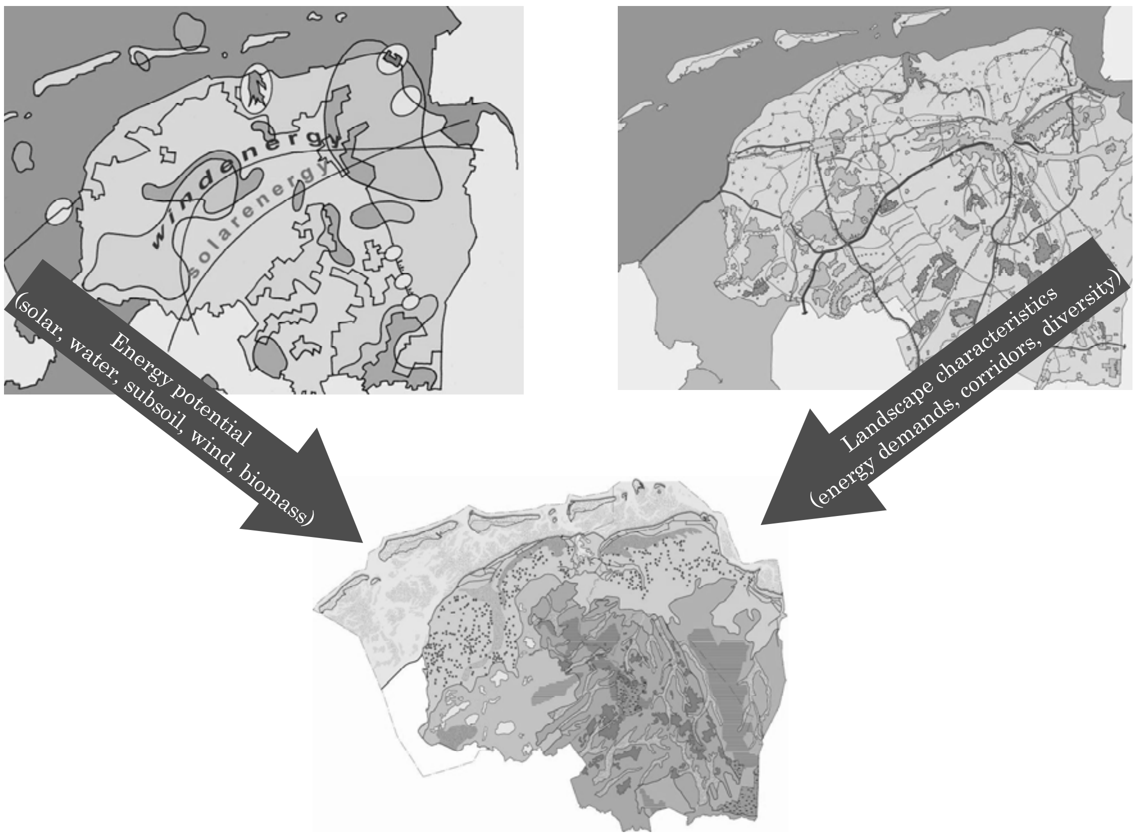

Figure 93 Example 'Energyscapes' from Northern Netherlands: A Sustainable Regional System Design is created by integrating the local and renewable energy potential with the characteristics of energy demands across the landscape

By adopting a long-term, 'one-system' perspective, the design team recognised a need for a radical transformation in both the region's energy system and the water and land forms. Similar to protecting the water catchment areas in the higher elevations, the system design for energy required that the local energy resources be mapped, classified and where appropriate, protected as functional elements within the urban regional system. Local energy resources include the dykes for windmills, the wilder upland regions for intensive biomass production, shallow aquifers for free heating and cooling water by season, deep aquifers and empty gas wells for geothermal heat (70C), natural gas fields, process heat and chemicals from the petrochemical industry in the NE, the causeway separating the Wadden Sea from the sweet water for use as a salt/fresh water battery, organic waste from cities for methane or biomass, and of course sunshine exposure for DHW and PV electricity.

Similar to the cascading of water through various qualities, so too it was imagined that locations with the highest energy quality are good for industry processes. Mid-quality energy is good for towns and cities that can benefit from heat – for example the biomass opportunities are excellent, especially if settlements are very close to the source or to suitable rail/boat terminals. Low quality energy sources are areas where quiet rural lifestyles are offered. The high quality energy cascades along transportation routes, and through an industrial ecology, creating an 'exergy' land use plan that minimise entropy in a manner is similar to gravity-based water shed planning. The lowest quality energy is captured in aquifers if possible, or used directly for space heating in buildings. Thus the energy 'landscape' serves to direct the location of cities, and other land uses throughout the region; the cascading chains of energy quality provide a further basis for land use planning – structuring the whole system for thermodynamic efficiencies. The energy content of water and materials means that functional integration must occur between the energy infrastructure, the water infrastructure and the organic waste infrastructure. The succession occurs as the old gas wells provide a convenient storage for other gas, and a means of accessing geothermal heat.

The remaining supplies of methane appears to offer an attractive bridge to a more sustainable system, as methane can surmount many of the obstacles without locking the parcels and cities into any one route or destination. Methane, as a transition fuel, can support electro-chemical technologies such as fuel cells, directly in molten carbonate and solid oxide fuel cells, reformed into pure hydrogen to fuel proton exchange membrane fuel cells, or converted into methanol and used in direct methanol fuel cells. Natural gas supplies can be supplemented over time with methane from local biomass digesters.

One of the most difficult design questions was how to localise the systems. Is it best to use methane to power micro-cogenerators at the scale of single buildings, sharing excess power on the electricity grid and using the free heat on-site? Or is it best to plan for district systems, that allow for localise networks of heating and cooling pipes, and that can be easily converted to new fuels and managed like micro-utilities? Such questions require a very interactive approach to energy and spatial planning. To assist with the localisation of solutions, the author prepared a vision statement based upon input from all participants, which attempts to capture the new design challenges in 'visionary' language. [GROUNDS 05]

10.4 The Systems Design Charrette

CitiesPLUS charrettes proved especially useful in structuring the visioning and exploration work by design teams, and engaging all of the sub-teams. Feedback indicated a very positive experience for participants. The charrette helped to build respect and understanding across very a diverse team – several participants referred to the charrette as a highlight in their professional careers. It also generated bold ideas and numerous original drawings. [*CitiesPLUS Charrette* Manual] The charrette results were presented to influential decision-makers and opinion-leaders, and helped to build momentum and acceptance. In the words of Condon, who helped to lead a *CitiesPLUS* charrette, a charrette is "The best way to get the most creative proposals to address the most difficult problems from the most accomplished designers in the most compressed period."

The *CitiesPLUS* integrated design process relied heavily upon the charrette process pioneered by Kelbaugh and Condon, as described in Chapter 5[41]. However innovations were required to address the extended time horizons, the staging of designs, the regional scale and the broad scope of the urban system. Referred to as a System Design *Charrette*, or SD charrette, the new approach was first summarised in the citiesPLUS charrette manual. The approach evolved as the SD *Charrette*s were conducted for *Bridging to the Future* in India, Europe and China.

In essence the SD charrette is an iterative design process modelled on the SEEIM framework that engages all of the ICDC actors in an intensive, accelerating, time-limited exercise. (Figure 94) The first stage is the research and preparation, including the scoping and information collection on the sites and systems. The second stage is an orientation session, during which the design teams review the design brief, visit the sites and discuss the relative impacts of design strategies. The third stage is the intensive design exercise, interspersed with presentations by experts, in which the teams explore design solutions. The fourth stage is a highly visual presentation to a VIP panel and to an audience of stakeholders and public by each of the teams. In the fifth and final stage the results of the charrette are published in a document and on-line. The publication can combine a polished version of the team presentations along with background papers

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[41] Condon and others at UBC continue to use charrettes as a key tool for transforming community plans, as part of a new program called *Smart Growth on the Ground*. Their program uses a charrette model that now integrates foundation papers and system-specific targets, building upon some of the *CitiesPLUS* innovations. See www.smartgrowth.bc.ca

and technical reports submitted by the specialists who participated in the orientation session. The *Bridging to the Future* Groningen charrette offers an example of such a publication. [GROUNDS 03]

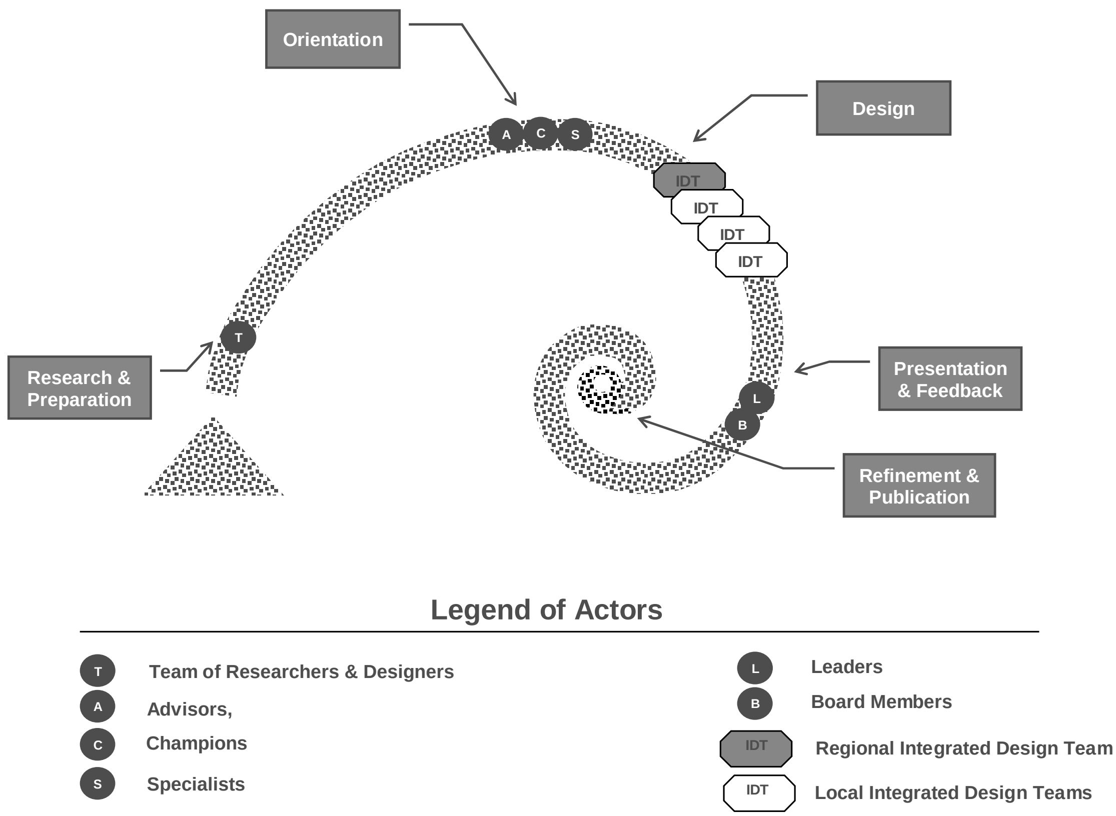

Figure 94 The SD Charrette is an accelerating process that involves many actors in each layer of the SEEIM framework

To some extent all design charrettes follow a staged process along similar lines. The most significant difference for an SD *Charrette* is the amount of prior research and education required in order to merge the physical design layers – land use, buildings and circulation – with the more systemic flows of energy, water, materials, nature and information. Such a merger is extremely difficult because it is so much a deviation from standard practice. Most designers work intuitively from a knowledge base that is rich in physical patterns but almost illiterate in the areas of LCA, MFA, and system dynamics. Especially at the regional scale it is difficult to absorb the details of systems that can affect long-term performance. Hence the core research and design team must develop a database, prepare succinct background materials, identify key specialists who can summarise the spatial implications of system design, and prepare computer models and maps that can present key information in a form easily understood and used by the designers.

Rather than a design briefing, the orientation session for the SD *Charrette* can be more accurately described as a combination symposium and workshop. Assisting with preparing and delivering the 'symposium' are the team's senior advisors, along with the champions for each sub-system and their specialists. The symposium can generate a series of papers and presentations that may be valuable in their own right, and can be included in the final outputs and publication.

Following the symposium is a workshop structured to give the designers and experts a chance to explore the issues raised by the symposium, and to identify gaps in their knowledge. The workshop may include a discussion of future forces and the implications of system design on spatial design. Without an opportunity to explore such issues the teams are less likely to integrate the unfamiliar concepts in their design submissions. Exergy landscapes for example, are a powerful concept for future system design but professionals need hours of interaction with experts to absorb the implications. Few designers have any understanding the spatial implications of distributed energy resources such as wind, solar, biomass, geo-exchange and micro-hydro. However once the concepts are well understood, then the natural intuitive abilities of the design professionals can often lead to highly creative solutions.

The orientation workshop is also a chance to explore the long-term targets so they become meaningful to participants who may be unfamiliar with the indicators and benchmarks. Even the goals for the design exercise will need discussion if participants are unfamiliar with the extended time horizons for design. The *Bridging to the Future* Shanghai charrette is a case in point.[42] The goal was to assist Qingpu District in achieving sustainable energy and water systems in 30 years. All the international experts started from the assumption that Shanghai and China as a whole had no option but to find an alternative route to that followed by developed western countries. Only in discussions with the local designers did it become apparent that most Chinese students and designers were convinced that the only route to sustainable system design was to first mimic the lifestyles and technology of the largest cities in the developed world. Like the developed west, they would take the time to discuss sustainability and long-term community design once they reached an equivalent level of development. An orientation workshop provides an opportunity to reconcile such opposing world views. During the evaluation session, two of the architecture

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[42] The charrette results are summarized in a book available at: www.bridgingtothefuture.org (China Book)

students in the Shanghai charrette referred to these discussions as a highlight[43].

The SD charrette must also grapple with extended time horizons and physical scales. Typically the design is staged over at least two time periods, to create a visual 'pathway'. The teams can each be given a different location and/or scale. If possible, the physical scales are nested, so that a region-wide design provides context for neighbourhoods, which in turn provide context for specific sites. The regional scale is more abstract and complex, and requires an especially experienced design team. Teams are encouraged to interact periodically, to align their approaches, which is part of the learning and which increases the potential coherency and clarity of the final designs.

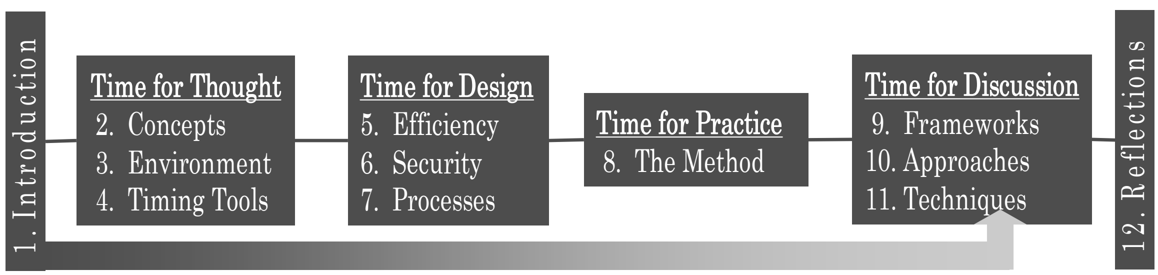
Because many participants in a SD charrette are non-design professionals, some technique is needed to assist them with participating in a way that adds value to the design. For this purpose, the SD *Charrette*s assigned architectural students to each team, with the task of assisting experts with expressing ideas through images. Students also stayed to enhance the visuals during evening hours. Although teams are not actually competing, the impeding presentations serve as an incentive for high quality outputs. As with other types of charrettes, the uninterrupted work time and the unusual mix of individuals provides a stimulating and productive environment.

One of the difficulties encountered with the SD charrettes is engaging practicing professionals and government officials for an entire week. This proved especially difficult in China, where the concept of integrated teams is very different from standard practice, and where hierarchical structures tend to prevent collaborative partnerships between government officials and academics. Despite extensive prior communications, the representatives from local utilities and government authorities attended the charrette only as occasional presenters or members of the audience. Participation was not considered appropriate. It may be impossible to execute SD *Charrette*s in some cultures without first achieving the very difficult core collaborative structure, such that each sector can use its very specific status and connections to influence the charrette plans, participants and potential outcomes. In China the core leaders and their supporting board should have embraced both academia and senior government – an unusual union.

[43] Personal conversations with the International Design Team and the Tongji University Architecture students in Jinze Town, April 2006

11 What Methods and Tools emerge to cope with new Time Concepts?

This chapter explores the challenge of new time concepts from the perspectives of coping with complexity and uncertainty. The exploration will follow the SEEIM design framework, examining selected innovations in methods and tools at each layer. Part of the intent is to explore how the design framework as a whole is transformed as a result of the time scales. Another part of the intent is to illustrate the potential for developing specific 'timing tools' that reflect a more cyclical and sustainable time concept. These timing tools are variations of the foresight methods discussed earlier, but adapted to the special situation of long-term urban system design.



11.1 Why is Complexity a Challenge?

Urban systems are the most diverse, long-lived artefacts created by humanity and thus it is not surprising that urban system design can be a complex exercise. Based upon the *CitiesPLUS* case study, the complexity of the design challenge appears to grow when time horizons are extended. Scenario planning, for example, can involve multiple design approaches at different physical scales, all of which must be evaluated at different stages, in different future scenarios, with respect to multiple goals. Resource efficient design also becomes more complex as the extended time horizons can lead to more integrated and inter-dependant systems. Resilient design introduces uncertain external forces, and can lead to intentionally diverse solutions as a way to make systems more flexible and adaptable. For these and other reasons, excessive complexity has become a recurrent theme in the research results.

Complexity may be an unavoidable – and even desirable – element of ecological design. However for the design teams the rise in complexity can translate into cost and frustration. At some point complexity becomes overwhelming, and is incompatible with a creative time-limited design process. The case study provides some indications of where complexity becomes a threat to successful long-term design. It is within this context that a number of questions need to be explored. What aspects of the system design proved especially challenging and required innovative timing tools? How was it possible to manage complexity during the design and decision-making process? Can the SEEIM framework be improved to better cope with new timing concepts?

Environmental Accounting and Complexity

As discussed in Chapter 4, sustainable design requires some degree of environmental accounting – tracking material and energy flows over time, and quantifying the associated effects and impacts. Stated more simply, an environmental accounting system is the conceptual framework for the environmental information used to assess the measure of sustainability. It includes as embedded elements all of the subnets and simulation models that are needed to track the relevant environmental indicators. [Moeller, 2002] Any change in the boundaries of what is included within this environmental accounting system may change the results of the analysis. If the boundaries are rational, stable and transparent, then the design team can obtain accurate evaluations and learn how to achieve sustainability. If not, then environmental information may be misleading and/or confusing.

A requirement for clear and defensible system limits holds for many types of analysis and assessment. Economic cost/benefit analysis, for example, can vary greatly depending upon what externalities are included, or excluded, from the bottom line. Hence the frequent arguments for Corporate Social Responsibility (CSR) and 'triple bottom line' reporting. What is unusual about system design for urban regions is the sheer scale of the accounting exercise, and also the potential for developing a 'whole systems' perspective, including the constructed environments and the natural systems upon which they depend.

This challenge of coping with complexity in design has two parts. On one hand the challenge is to communicate the essential dynamics of the urban system to a broad cross-section of professionals and public, so they can develop a more intuitive, holistic knowledge of how design changes might impact environmental performance. On the other hand, the challenge is to provide decision support tools that are easy and quick to use, and that can be adapted to deal with the increasing complexity as design team cycles through the SEEIM framework.

Lynch has summarized the balancing act for complex decision-making tools. "The complex techniques now used for forecasting and discounting the future open a gap between planners and planned. A community faced by an intricate professional calculation showing that future growth will require so many lanes of new highway has no way of disputing that prediction. By its complexity, its unfamiliarity and polish, the prediction has majestic authority. […] Computers may become a new weapon for elitist planners, yet they also could be used to diffuse information to everyone who needs it. At any rate, long-range planning and 'futurism' have become anathemas to those committed to democratic participation. […] The remedy is to demystify (and sometime's debunk) sophisticated forecasting techniques and to make them available to local groups for the preparation of alternative predictions." [Lynch 1993] The same could be said about forecasting techniques for the design teams as well.

Do better decision-support systems offer a way to simplify the complex environmental accounting so that design teams can forecast long-term performance and assess sustainability? It appears that the problem is not a lack of tools. For example, the International Energy Agency Annex 31 web site describes hundreds of software tools for use with whole buildings, and dozens of tools for use in urban modelling[44]. but a lack of context. A continuing difficulty during the CitiesPLUS work was confusion over when and how to use conceptual and analytical tools. These tools are not designed for use in combination, as part of an integrated design exercise. They use different terminology for the design process. Most are not web friendly. Databases are not designed to be shared, - other than very crude data such as weather files - and thus tools cannot draw from common data sets, nor enrich datasets for use by subsequent analysis.

More problematic than any of the above, is the confusion over when tools are to be integrated into the design process. This confusion often arises from claims by ambitious tool developers that imply greater utility than is possible with any single tool. A lack of user-scalability is another problem. However real issue seems to be that the tool developers are often focused only a single stage in the many-staged design process, and have not actually given much thought to how one tool fits into the process, and how tools hand-off to other tools. This required an exercise for DSS team to try to fit tools into the planning framework – and a graphical illustration in the final design the situated all DSS tools on the SEEIM framework [www.*CitiesPLUS*.ca Tools]. This in turn placed still more emphasis on the value of adopting a common framework that can be used to coordinate all activities, including modelling and analysis. A common framework, however, introduces other difficulties, as explained below.

11.1.1 Funnels in the Framework

The use of a hierarchical design framework like SEEIM is only a partial solution to complexity. While it can simplify communications and help to

[44] The author served as the Canadian representative on the IEA Annex 31 and assembled all of the information on specific tools listed on the web site:

organise the tasks and players, it can also generate an almost overwhelming amount of information as each goal is unbundled into a nested, spreading series of increasingly specific design decisions. A framework needs to be simplified at each stage by an accounting and valuation system that is designed to condense information and reduce complexity.

In the process of applying the SEEIM framework in the *CitiesPLUS* case study, an effort was made to manage the quantity of information and the complexity of the task. Initially this was only a question of limiting the scope of the exercise. However it became an on-going process of prioritization and simplification.

The effect of simplification is to place 'funnels' in the framework at every level. Figure 95 illustrates the progression, as the SEEIM framework first expands to accommodate the excessive information load, and then is redesigned with funnelling tools that reduce the information emerging from each level.

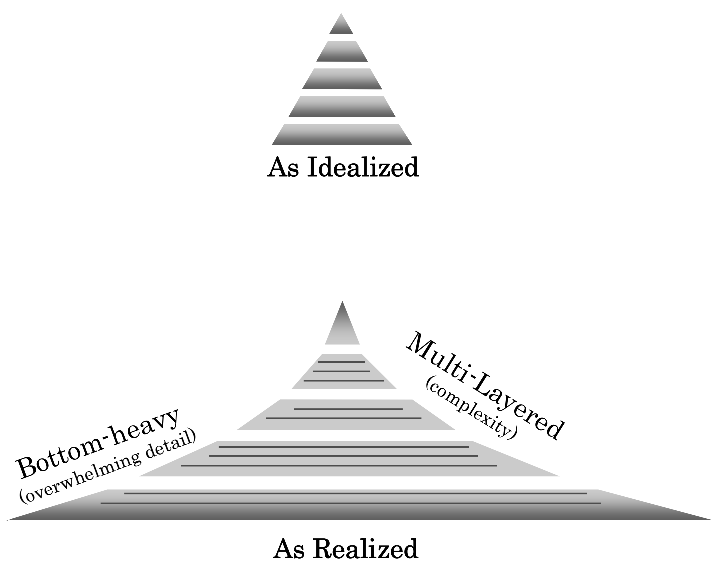


Figure 95 The SEEIM Framework is unmanageable without tools for simplifying the framework as it becomes more specific

The precise nature of the funnels varies at each level. For example, at the Envisioning level a core set of primary indicators is used to simplify the accounting. At the Exploring level the strategic design choices are condensed into a series of 'catalyst strategies'. Essentially the funnels are any tools that counteract the increasing volumes of information within the design process. They can also be described as 'timing tools' that serve to manage complexity in long-term designs. Many of the timing tools are variations of the basic foresight methods described in Chapter 5 of this thesis.

At the top of the framework are the tools for integrating the design and decision-making process, categorising and scoping the systems, and developing an appropriate systems perspective. These tools have already been described.

Seven *CitiesPLUS* timing tools are described in the remainder of this Chapter, one or two for each of the remaining levels of the SEEIM Framework. Figure 96 introduces each of the tools by name, and identifies where it fits into the SEEIM framework. The selected tools were developed as a part of the *CitiesPLUS* research. Additional commercial tools were also applied.[45] The application of these new and existing tools helps to shed light on one of the key questions of this thesis: how can design frameworks accommodate extended time horizons? The focus of this chapter is on conceptual tools that are specifically adapted extending time horizons of the SEEIM framework.

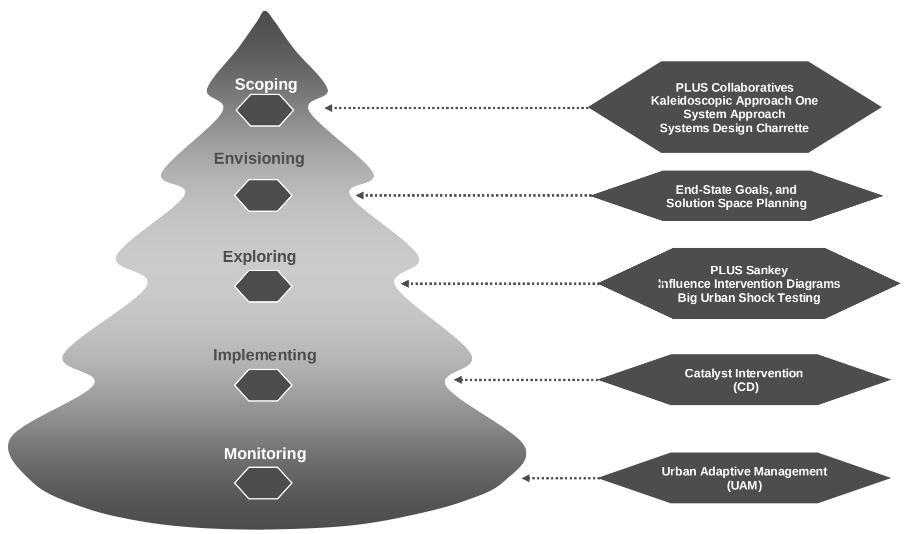


Figure 96 Specific timing tools are used to manage complexity at each layer

[45] Other tools sometimes proved helpful in managing change. For example, envisioning can be supported by the Quest model (www.envisiontools.com). Exploring can be supported by Community Viz (www.placeways.com) and Infracycle (www.infracycle.com). Implementing can be supported by software for feasibility analysis and engineering, such as RetScreen (www.nrcan.gc.ca/retscreen)

11.2 Methods for Long-term Envisioning

11.2.1 End-State Goal Setting

Although it is not usually apparent to those engaged in sustainable design, the large majority of visioning work is currently restricted to short-term goal-setting. The goals are short-term because they indicate the direction or behaviour that is most needed in the short-term, as opposed to the ultimate desired condition, or destination.

Short-term goals often begin with words like “minimize”, “improve”, “reduce”, “enhance”, “create”, and “apply”. Essentially they are strategic statements, or objectives, that reflect agreement on what constitutes current problems and, in some cases, assumptions about what are the necessary strategies or desired directions of change. In the language of ecology, short-term goals describe the “response” required by systems to cope with “stressors”. In the language of time scales, they are goals that conform to the time rings of the governance system and economy, within an extended present.

Once end-state goals have been established, the short-term goals become interim targets on the ‘pathway’ to sustainability, as shown in Figure 97. The short term goals reflect a strategic approach, which requires a time horizon sufficiently close to predict the impacts of key driving forces like technological innovations. Depending upon the time rings for the design elements, and the pace of change desired, the absolute time periods for a ‘short-term’ horizon will vary.

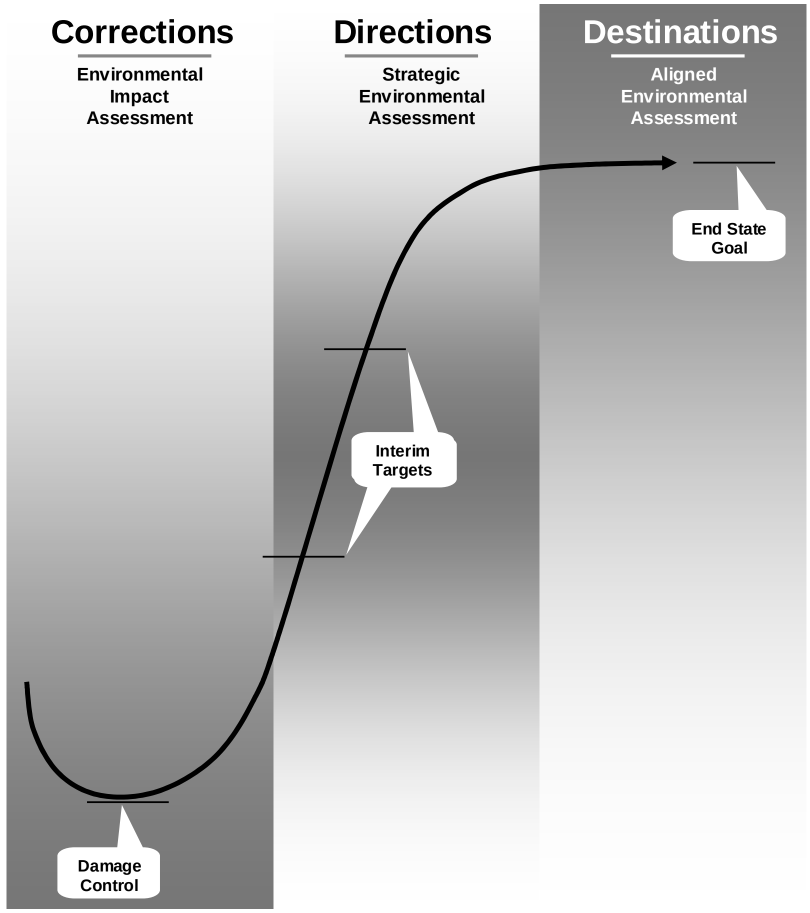


Figure 97 The shape of a pathway is defined by interventions, interim targets and end-state goals

As discussed in Chapter 9, the 100-year time horizon is an arbitrary limit that is sufficiently far out to allow for inclusion of slow-moving elements, to introduce significant uncertainty, and to manage the resolution of problems in a staged fashion. One initial criticism of 100-year horizons is that they are so distant that almost anything can happen. In the context of Envisioning, that is the whole point. A 100-year goal is usually viewed as the 'far future' in the utopian sense defined by Nowotny, rather than an extended present.

Long-term goals are thus an attempt to define the ultimate "state" of affairs that is desired, rather than a 'response'. In *CitiesPLUS* the long-term goals were referred to as 'end-state' goals, to help participants understand this difference. End-state goals are not necessarily action-oriented - although they may include a completion date, or imply a new approach. Figure 98 lists the end-state goals for one urban system: Security. Working with the sub-system teams over a period of three months, it was possible to create 206 end-state goals, or about 10 to 12 goals per sub-system.

Human Security Systems

End-State Goals

1 The region participates directly in international networks of cities that work to identify & mitigate all types of threats.

2 All major governmental, civil, and private sector organizations within the region cooperate in integrated threat management and in the implementation of risk management strategies which emphasize protection and prevention.

3 The region is a place where the vast majority of residents feel safe and secure at home and in their communities.

4 The region experiences extremely rare incidents of white-collar crime, street crime, and organized crime.

5 Residents of the region have the knowledge, experience, and capacity to allow them to work with neighbours to minimize the impact of shocks and to look after their short-term needs in the event that key urban systems fail.

6 The governance system is capable of responding quickly and effectively to possible threats by informing residents, collecting data and knowledge from residents, and educating residents on possible trade-offs.

7 Critical urban infrastructure systems have been designed to withstand a wide range of threats.

8 Ecological systems that provide the essential natural resource requirements to the region are subject to on-going risk assessment and, where possible, incorporate redundancies to ensure that the loss of any one system can be survived.

9 Each community in the region has a coordinated network of police, fire, ambulance, coast guard, and public works personnel capable of providing a range of first aid and emergency services in response to a full range of threats.

10 A cellular structure throughout the region prevents the cascading of problems from one neighbourhood to another or from one urban system to another.

11 Capacity and resources exist within the region to allow for the rapid repair or replacement of critical infrastructure and the recovery of the physical and psychological health of responders and impacted residents.

12 Urban environments and governance systems are designed to avoid or minimize loss of life and property damage from floods, earthquakes, fires, and windstorms.

13 Regulations, enforcement, surveillance and planning methods strike a balance between protecting personal safety, allowing individuals a large measure of privacy and the freedom to choose their lifestyles.

14 The region uses an intelligence system that is capable of dealing with rapid rates of change and high levels of uncertainty.

Figure 98 End-state goals were created for each urban system and represent a final desired condition or destination

Exploring end-state goals is what Lynch describes as 'future preservation' – a process analogous to historical preservation. In this sense visioning can help to clarify what notions of the future are special, and worth retaining, and what notions might be regarded as insignificant, irrelevant, meaningless, confusing, out-of-date or excessively short-term.

The *CitiesPLUS* foundation research on forces of change helped to clarify the level of uncertainty for urban systems, and differentiate the short-term and long-term scales. As a conceptual tool, a variation of *The Natural Step* (TNS) funnel was developed and used to illustrate the margin of action for specific types of problems. An example of the funnel is shown in Figure 99, where the funnel opening is the measured ecological footprint of the urban systems.

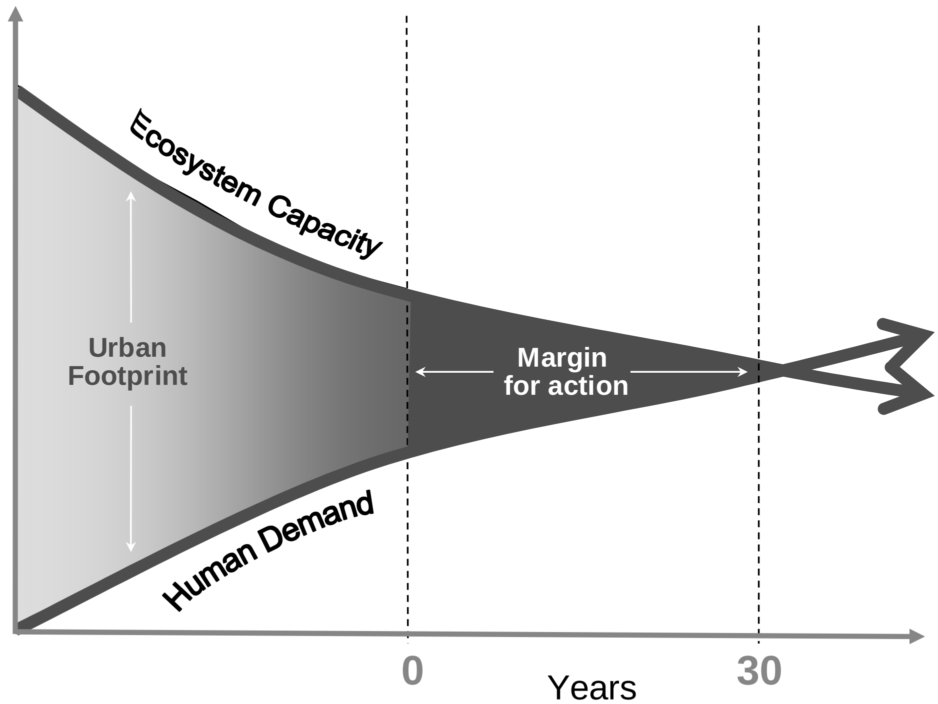


Figure 99 A variation of The Natural Step funnel for backcasting pathways to sustainability

The upper wall of the funnel is the ecosystem capacity – which is dropping due to erosion, toxification, urbanisation and loss of habitat, and species extinction. The lower wall of the funnel is the demand for nature's services, which is rising due to population growth, rising standards of living, and materialism. Figure 100 shows an alternative pathway in simple terms: regeneration opens the upper wall; dematerialisation opens the lower wall; and a much smaller ecological footprint satisfies the both the systems limits and the pinch points over a thirty year horizon. Thus the funnel becomes a simple heuristic for discussing both short and long-term challenges for the urban system as a whole.

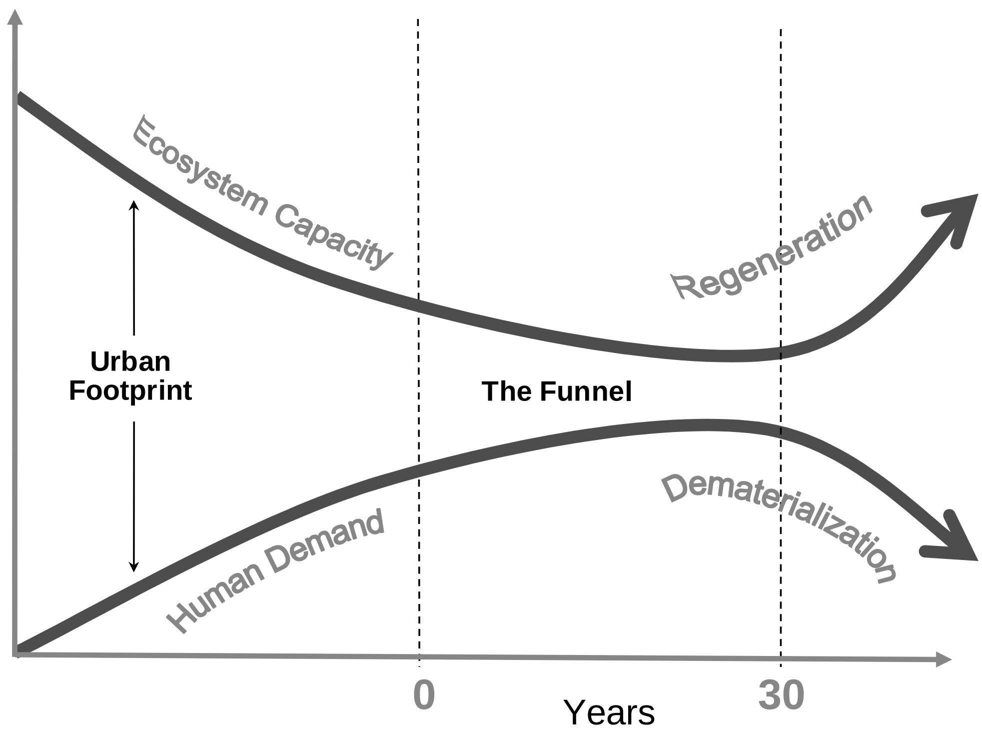


Figure 100 A simplified view of sustainable development forces

Whether the long-term goals are expressed as system conditions, or end-states, the framework must translate these limits into measurable performance indicators suitable for use in target-setting, strategic planning, and assessment. In the context of urban design, the monitoring targets are not intended to directly guide the design strategies. They are rough parameters used to indicate and inspire a level of effort. Targets help to manage a transition so that the region can satisfy constraints, take advantages of opportunities, and generally achieve the longer goals in a managed and cost-effective way.

End-state goals are sometimes easy to quantify because the end-state can also function as a kind of metric. The TNS 'system conditions' are examples. In *CitiesPLUS* an example of a measurable end-state is: "***Net Gain****: The energy content of locally grown food exceeds the energy value of purchased agricultural inputs, including commodities, equipment, and fuels.* " [www.*CitiesPLUS*.ca EndStateGoals]   Sometimes it is possible to express the state in the same terms used for short-term goals. In such circumstances, the short-term goal is interpolated. However a different indicator is often needed in the short-term so that the measurement provides a more direct feedback on the strategic objectives.

In *CitiesPLUS*, approximately 25% of the end-state goals were converted into short-term goals using indicators. Each indicator was provided with a measurement protocol, a simplified version of which is illustrated in Figure

101. As shown, each of the *CitiesPLUS* indicators was provided with appropriate benchmarks. Benchmarks proved to be one of the most important and time-consuming research tasks within the Envisioning layer. No indicator – or measurement – has any meaning without comparables. Up to a point, the more comparables the easier it becomes for the collaborative team to become familiar with the indicator and to set appropriate targets.

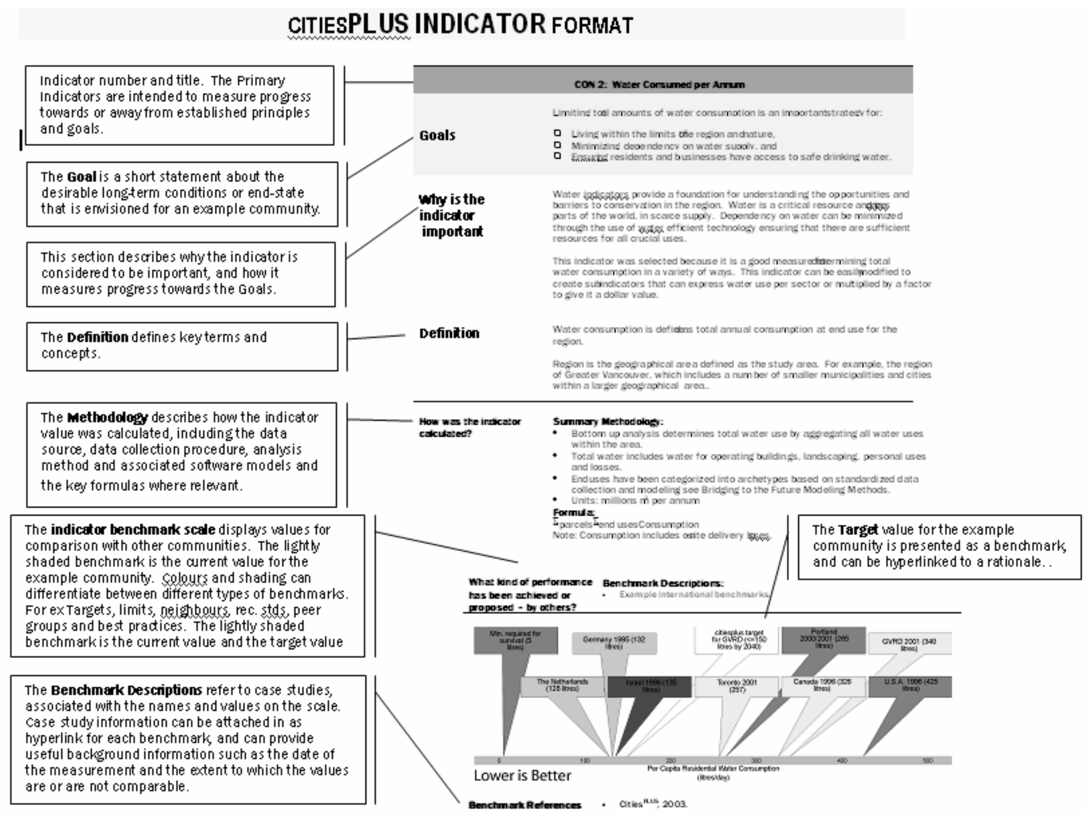


Figure 101 A generic format is used to describe each of the core indicators

Benchmarks drawn from other locations may require a considerable investment in research in order to properly understand the results, and in particular to record any differences in the measurement protocols so that the design team is not misled. Time required for benchmarking amounted to one to three days per indicator[46]. In the absence of a publicly accessible database on urban performance indicators, research costs represent a natural limit on the benchmarking.

All benchmarks were displayed on benchmarking scales – a visualisation software tool developed by the author for Envisioning within *CitiesPLUS*.

[46] Review of time accounts for core team researchers, from The Sheltair Group.

Figure 102 zooms in on the benchmarking scale shown earlier, comparing water consumption among the SUSD regions, and including the current status and short-term target for Greater Vancouver. The scales lack any vertical axis, and thus are easy to use in an IDCD process, where both designers and decision-makers tend to be unfamiliar both with reading statistical graphs, and with the specific units of the performance indicator.

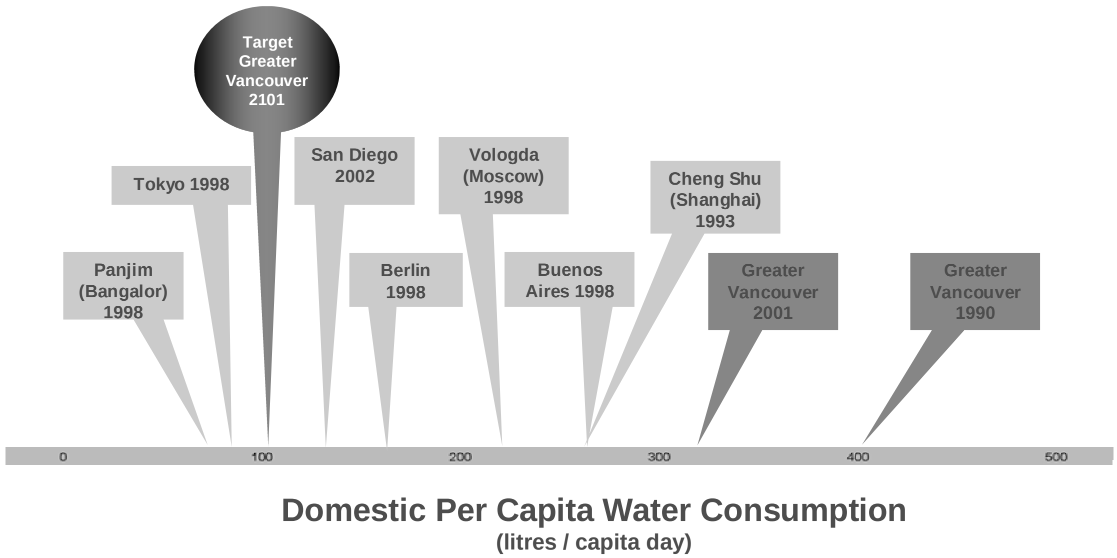


Figure 102 A Benchmarking Scale is a convenient tool for introducing indicators and targets in a non-technical format; each benchmark is hyperlinked to a case study or fact sheet

Water consumption is a 'core' indicator for environmental accounting in *CitiesPLUS*. The concept of core indicators is to create a discrete list of indicators suitable for monitoring the urban metabolism, and for setting targets on the pathways for energy, water and materials. By reducing the measurement parameters, core indicators function as a 'funnel' for reducing the complexity of the framework and design results.

Seven core indicators were proposed: consumption, demand, capacity, diversity, emissions, costs, and sustainability. Figure 103 provides a more detailed description. The first four indicators are referred to as primary indicators, since they are absolute values that have been aggregated from the regional model. These primary indicators have many potential sub-indicators that can be created simply by normalising the core indicator. For example, consumption can be normalised by person, by sector, by resource type, by end use or any combination of the above. The remaining core indicators are of two types: transposed values that convert primary indicators into other terms - for example consumption can be expressed in terms of monetary costs or emissions; and composite values that express a ratio of the primary indictors – for example demand as a percentage of capacity.

Core Indicators

CON 1:	Energy Consumed per Annum	*Primary*
CON 2:	Water Consumed per Annum	*Primary*
CAP-1:	Annual Average Local Energy Capacity	*Primary*
CAP-2:	Annual Average Local Water Capacity	*Primary*
DEM-1:	Peak Energy Demand	*Primary*
DEM-2:	Ratio of Peak Energy Demand to Capacity	*Composite*
DEM-3:	Peak Water Demand	*Primary*
DEM-4:	Ratio of Peak Water Demand to Annual Average Capacity	*Composite*
EMI-1:	Total GHG Emissions from Energy Consumption	*Derivative*
MON-1	Monetary costs to Consumers of Annual Energy	*Derivative*
MON-2	Monetary costs to Consumers of Annual Water	*Derivative*
DIV-1:	Number of Energy Sources that provide > 5% of Total Consumption	*Composite*
DIV-2:	Number of Water Sources that provide > 5% of Total Consumption	*Composite*
SUS-1:	% Energy Derived from Sustainably Harvested Renewable Sources	*Primary*
SUS-2:	% Water Derived from Sustainably Harvested Renewable Sources	*Primary*
ECO-1:	Ecological Footprint in Ha / person	*Derivative*

Figure 103 Core energy and water indicators may include different categories of indicators

These core indicators, in combination with end-state goals, provide a standard environmental accounting system that works for energy, water and materials, and that can be benchmarked against any other region that adopts a systematic approach to MFA modelling. Part of the difficulty with trying to standardise and employ such end-state goals and targets is the lack of agreement of how to define and present the long-term system dynamics.

Ideally the performance indicators will also be scalable. High-level indicators are needed for targeting and monitoring overall performance at the regional scale. These can then be translated into low-level indicators suitable for use by design practitioners and contractors. For example a high level target based upon the measured quality and quantity of storm water flows after development can be translated into a low-level target based upon the designed on-site storm water storage capacity and surface permeability. The logical connections between high and low level measurements can be provided through the framework of scalable LCA, as described in Chapter 4. An explicit structure of life cycle oriented mass, energy and money accounting system is necessary to avoid inconsistencies.

11.2.2 Solution Space Planning

Managing the pace of change in urban systems is complex, as it must integrate what is practical with what is desirable and necessary. Each sub-system, requires thought in order to design a manageable transition strategy for each goal. In *CitiesPLUS* change management was addressed by defining a solution space over time. The result is a conceptual tool for managing the speed of change, referred to as Solution Space Planning (SSP).

'Solution space' is a term that was originally employed in mathematics to indicate a limited range of correct answers, or solutions, for a given problem. A solution space provides an envelope or corridor of acceptability – or sustainability – relative to quantifiable measures of performance. The concept of solution space was found to fit well into the long-term planning process, where managing change requires ability to trade-off between a variety of possible solutions, without over-stepping fixed constraints like the peak capacity of infrastructure systems, or financial affordability.

Solution space polygons can be created graphically by plotting three variables, each of which has upper and lower limits. The polygon is the space the satisfies the limits of all three variables. Nicole Miller[47] has used this approach to explore the strategic options available for reducing greenhouse gas emissions in an existing suburban neighbourhood in Greater Vancouver. [MILLER 06] Her solution space polygons are shown in Figure 104. In this simple example, the target is to reduce greenhouse gas emissions by 75% or 50% or 25%. As shown, this can be achieved through various combinations of transportation emissions reductions, building emission reductions, and increased on-site renewable energy generation. Each of these variables will have a lower limit (commitments or trends already in place) and an upper limiting factor (the technological, economic or social potential for change). The polygon in the example illustrates the manner in which the three strategies can be combined to achieve the target, without overstepping these limits.

Choice of a preferred location within the solution space polygon may require a multi-attribute trade-off analysis, and would vary depending upon the norms of decision-makers. Additional variables may be considered, although multi-dimensional solution spaces become difficult to interpret.

[47] This format for presenting polygon solution spaces was developed by Nicole Miller, UBC Architecture student, who has worked with the author to enhance *CitiesPLUS* methods

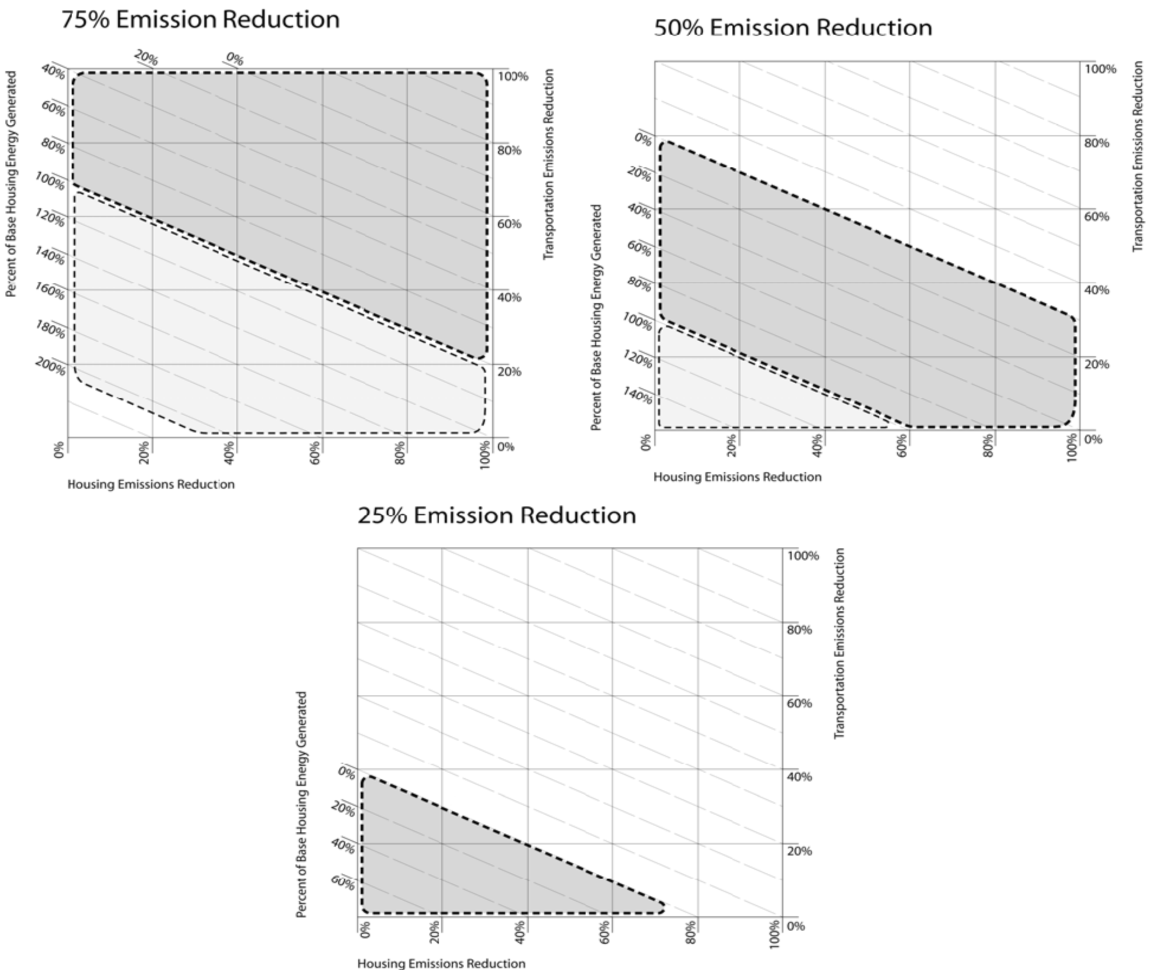


Figure 104 Example of Solution Space polygons for an existing suburban development in Greater Vancouver; each polygon represents combinations of values for three variables shown (transportation emissions, building emissions and on-site energy) that will satisfy the specified target for CO2 emissions [MILLER 06]

Solution Space Planning combines with time extensions to produce a more strategic plan for achieving targets in system design. The process can best be described by means of a second illustration. Figure 105 is a solution space corridor developed in *CitiesPLUS* for reducing fossil fuel use over the 100-year time horizon. The x-axis of the graph measures time in years; the y-axis measures performance towards an end-state goal – in this case defined by a composite indicator: % of total energy supplied by renewable resources.

The '*Current Performance* ' is approximately 25% renewable energy for Greater Vancouver[48]. The end-state goal is 90% renewable.

The '*Trend Line* 'for Greater Vancouver reflects existing plans by BC Hydro for combined cycle natural gas thermal generation in the Fraser Valley. Since the trend line is in altogether the wrong direction, new policy is probably required for sustainable urban design.

The '*Critical Path'* shows a slow reversal of trend – presumably as a result of new policies – following a manageable 'S' curve to the ultimate destination of 90% in year 100. In crude terms, if the urban region performs below this critical path, it becomes at risk of a contributing to costly dislocations - brown outs, trade restrictions, climate change, and uncompetitive business.

The '*Preferred Path'* represents a managed transition to the end-state over a shorter time period of 60 years. Any faster and the change process appears to become untenable, forcing premature obsolescence onto the region's capital investments, and requiring that citizens embrace new technologies or new behaviours at a 'crisis' speed. The concern is that a crisis rate of change will backfire on the politicians and decision-makers.

The '*Solution Space'* for the urban system is the area between the Critical Path and the Preferred Path at any point in time. Planning to remain in the solution space at all times means staying within a '*Solution Corridor*', which ensures that goals are achieved without the risk of moving too slow, or too fast. Movement within the solution space will be subject to interactions between this end-state goal and other goals such as economic prosperity, resiliency, air quality and livability. Conflicts with other goals may mean lower performance; positive synergies with other goals may allow higher performance.

'Interim targets 'are short-term goals and thresholds that can be established for any date, simply by noting where the year intersects with the two pathways. Ideally the critical path is established with the assistance of scenario planning tools that address existing policies and mega-trends. The pathway for sustainable water demand in Greater Vancouver, for example, was adjusted to account the expected reduction in summer precipitation - and reservoir capacity – from climate change.

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[48] This is a controversial number, since the hydro electricity from the existing large dams in the interior of the province has been categorized as renewable. This decision reflects discussion personal discussions with the dam engineers about the expected lifetimes of the systems, but is not consistent with current definitions of 'green' electricity.

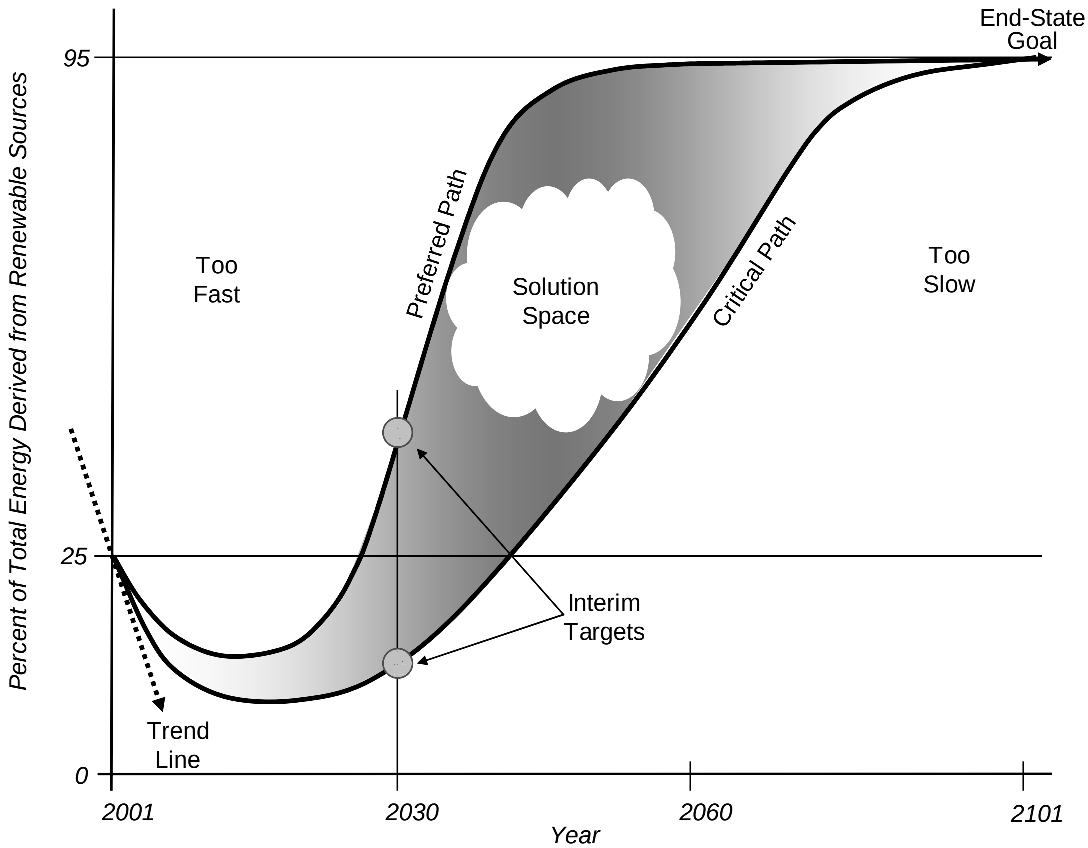

Figure 105 A Solution Space corridor is bounded by both a critical path and a preferred path, each designed to achieve the end-state target

For most elements of urban systems the '100-years or bust' time horizon is an arbitrary, but convenient planning tool for setting lower limits when sustainability might be achieved. Only the slowest moving elements, like bridges, ports, canals and highways have transition times in excess of100-years. That said, it is unclear how to reconcile the 100 year end date with the many other procedures that can be used to establish long-term targets. For example, an international treaty on Climate Change may identify time limits for stabilizing CO2 emissions that reflect the risk, or that represent a 'tipping point' for the natural negative feedback systems that maintain the biosphere and climate. While Solution Space Planning is easily adapted to such alternatives, the tool lacks a process for varying the time scales, and for integrating different strategies into a shared solution space. It is also not clear how to effectively layer the solution spaces for multiple end-state goals that share common scales, and visualise a multi-dimensional solution space. Such a procedure is potentially needed to assist with optimizing the trade-offs within a complex decision-making process.

11.3 Methods for Exploring Long-term System Dynamics

11.3.1 PLUS Sankey Diagrams

Sankey diagrams were used both by *CitiesPLUS* and by Team India to develop and illustrate 100-year sustainable urban system designs. Collaboration between the international teams resulted in an expanded toolkit of analytical models and data collection methods, based largely upon the structure and scope of Sankey diagrams. The diagrams appeared to serve as a tool for holistic thinking - a 'designers' window' into urban metabolic modelling and LCA for urban systems. They also provided concise and rapid approach to visualising the results of environmental accounting at scales from parcel to region. Ultimately the Sankey diagram became a heuristic for structuring the database for regional environmental accounting. As an outcome of this research, a new approach has emerged on how to employ the Sankey diagrams for use in long-term design.

In order to explore the potential for a Sankey tool it was first necessary to develop a standard format and method. It was also necessary to develop simple tools for collecting, processing, aggregating and transposing data. The combination of standardised formats for presentation, and integrated data management, will now be referred to as a 'PLUS' Sankey.

Through standardisation, it becomes possible to develop and maintain a database with sufficient scope and precision to generate the system diagrams for environmental accounting at every stage of the SEEIM framework. The standardised structure also makes it possible to directly compare results from different locations or different time periods, creating the comparable benchmarks so useful for target-stetting and strategic design.

Sankey Architecture

Parcels include discrete pieces of land with any attendant buildings. Spatial boundaries are typically defined from cadastral data[49]. Since the parcels all share an identical data structure, they can be aggregated into user-defined clusters of parcels, such as development projects, neighbourhoods and cities, right up to the regional scale, while still retaining balanced input-output.

All data collection occurs at the scale of an individual parcel, where flows are recorded in a pre-defined matrix that corresponds with the Sankey diagram structure, connecting the flows for each node on the parcel with nodes upstream or downstream. The matrix cross-references flows in and

[49]In Shanghai, China the lack of clear property divisions required that parcels be defined arbitrarily as polygons surrounding buildings

out of each partition and node – a numerical equivalent to the Sankey diagram. Such an Excel matrix is automatically generated either from the empirical data collected on each archetypal parcel, or from hypothetical data representing advanced parcel design.

The data processing included thermal models for predicting energy demands. Water flows are predicted on the basis of primary data such as type of appliance, number of occupants, and so on.

The visualization software creates a Scalable Vector Graphic (SVG) from an XML file that is generated from the Excel matrix derived either from a database file, or from a Visual Basic Graph User Interface (GUI). These different utilities provide flexibility. Both the database and the Excel matrix can be used to directly generate diagrams. Or the user can choose to use the Visual Basic GUI to modify values, add text or numeric values to the nodes and edges, colours, hyperlinks and other features. The hyperlinks are especially useful, as they allow for nested Sankeys; touch an edge and a new Sankey appears with greater resolution on flows between partitions. Hyperlinks also allow for ready access to written descriptions, photos, and other background information on particular nodes and edges.

Creating PLUS Sankeys for the international case studies required a robust data collection tool, capable of accommodating buildings as diverse as slums in Southern India and apartments in northern Netherlands. Figure 106 shows an excerpt from the Excel software developed for energy and water data collection. These computerized forms were designed to collect all the information needed to calculate the core indicators. In addition, and unlike other aggregation models, all the connectivity is also recorded so that it becomes possible to chart the flow paths in a matrix and diagram. For example, the forms record exactly where the roof drainage water is output – to ground, cistern, street, garden, sewer, storm drain, or wherever.

VATER DEMAND	Units	Values	Comments	List of Options											
Laundry															
Clothes washing system		Full size stnd top loading		None	Full size stnd top loading	Full size, side load or short cycle	Compact (45 liters) top	Compact (45 liters) side load	Advanced water efficient	Basin					
Number of full loads created	per person week	1		0	0.5	1	1.5	2	2.5	3					
Washing appliance consumption	liters per load	120													
Personal Hygiene															
Shower use	per person week	3		0	1	2	3	4	5	6	7	8	9	10	11
Bath use	per person week	2		0	1	2	3	4	5	6	7	8	9	10	11
Shower system and length		Standard Short (5 minutes)		None	Standard long (8	Standard Short (5	Low Flow Long	Low Flow Short	Bucket						
Bath		Full		None	Full	Normal	Bucket								
Hand & face, shaving, brushing		Tap on constantly & long		None	Tap on constantly &	Tap on constantly	Tap on constantly	Tap off except when							
Showering system	liters per shower	100													
Bath	liters per bath	162													
Hand & face, shaving, brushing	liters per person	100													
Kitchen															
Cooking Frequency	meals per person day	2		0	1	2	3	4	5	6					
Dishwashing System		Stnd Machine		None	Basin or Sink	Stnd Machine	Water Eff. Machine								
Number of full loads created	per person week	1		0	0.5	1	1.5	2	2.5	3					
Dishwashing system	liters per load	60													
Toilets															
Primary toilet water system		Standard flush		None	Standard flush	Low flush	Low volume dual flush	Extra low w/ dual	Compost Toilet	Latrine with faucet					
Primary toilet use	flushes per person day	4		0	1	2	3	4	5	6	7	8	9	10	11
Secondary toilet water system		None		None	Standard flush	Low flush	volume dual flush	Extra low w/ dual	Compost Toilet	Latrine with faucet					
Secondary toilet use	flushes per person day	0		0	1	2	3	4	5	6	7	8	9	10	11
Primary toilet category	liters per flush	22													
Secondary toilet category	litres per flush	0													
Drinking															
Irrigation															
Cummulative operating time for all irrigation pipes & outdoor watering taps (excluding reuse of wash water)	hours per month	0		0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	
Potted Plants and Pools															
Typical quantity of water per month	liters per month	2		0	2	4	6	8	10	12	14				
Interior Surface Cleaning															
Frequency of interior surface cleaning	times per week	7		0	1	2	3	4	5	6	7	8	9	10	11
Quantity of water used (excluding reuse of wash water)	liters per event	4		0	1	2	3	4	5	6	7	8	9	10	11
Exterior Surface Cleaning															
Days per month exterior surfaces cleaned	number of days	0		0	1	2	3	4	5	6	7	10	15	20	25
Duration of watering	minutes per cleaning	0		0	5	10	15	20	30	45	60				
Vehicle Cleaning															
Number of 4 wheel vehicles cleaned on-site	number of vehicles	2		0	1	2	3	4	5	6	7	8	9	10	11
Number of 2 wheel vehicles cleaned on-site	number of vehicles	0		0	1	2	3	4	5	6	7	8	9	10	11
Frequency of cleaning	per vehicle each week	1		0	1	2	3	4	5	6	7				
Evaporative Cooling															
Typical frequency of use during hot months	hours per month	0		0	50	100	150	200	250	300	350	400	450	500	550
Category of cooling system		None		None	Small (residential), no bleed	Multi-unit, no bleed	Large	Small with bleed	Multi-unit with bleed						

WATER CONNECTIONS

Input Systems for Satisfying Water Demand		Parcel ID	Percentage of water provided to each end use by the Input System												
			Laundry	Personal hygiene	Kitchen	Toilets	Drinking	Irrigation	Potted plants and pools	Interior surface cleaning	Exterior surface cleaning	Vehicle cleaning	Evaporative cooling	Humidification	Client demand
Direct precipitation	Source														
Roof run-off into storage tank	Source														
Pond	Source														
Reservoir	Source														
River	Source														
Lake	Source														
Ground water	Source														
Aquifer	Source														
Ocean	Source														
Transported as bottles imported into region	Source														
Imported as raw water via pipes into region	Source														
Purification system	Converter														
Well and pump	Converter														
Mixing system	Converter														
Water factory for region	Converter														
Water factory for neigbourhood	Converter	A	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Water storage tank	Converter														
Regional water pumping station	Converter														
Desalination plant	Converter														
Clients for water	Converter														
Custom water input 1	Converter														
TOTAL ALLOCATION OF INPUTS			**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Ouput Systems for Receiving Water After Use		Parcel ID	Percentage of each End Use Connected to the Output System												
			Laundry	Personal hygiene	Kitchen	Toilets	Drinking	Irrigation	Potted plants and pools	Interior surface cleaning	Exterior surface cleaning	Vehicle cleaning	Evaporative cooling	Humidification	Client demand
Septic tank	Sink														
Detention pond	Sink														
Reed bed	Sink														
Infiltration trench	Sink														
Oil trap & drain	Sink														
Planter with infiltration system	Sink														
Constructed wetland	Sink														
Sluice & floodway	Sink														
Run-off onto surrounding hard surfaces	Sink														
Lake	Sink														
River	Sink														
Run-off and infiltration into surrounding ground	Sink														
Aquifer recharge	Sink														
Ocean	Sink														
Evaporation into air	Sink														
Exported from region in pipes	Sink														
Exported from region in trucks	Sink														
Exported from region in pipes	Sink														
Gray water recycling system	Converter														
Storage tank for pumping to truck or boat	Converter														
Sewage teatment plant regional	Converter														
Sewage teatment plant neighbourhood	Converter	A	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	
Reclamation plant	Converter														
Clients for water	Converter														100%
Custom water output 1	Converter														
TOTAL ALLOCATION OF OUTPUTS			**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Figure 106 Computerised Forms used to generate, filter and transfer essential MFA data on water demand and water connections

The data collected on each parcel is automatically processed and transferred to a universal matrix structure (Figure 107). A matrix can be generated for water, energy or material flows, and then used to directly produce the xml files used for diagramming any MFA flows in Sankey format.

		FLOWS INTO:															
	Exported from region in pipes	Source											Upstream Converter	Demand at Parcel	Downstream Converter	Sink	
FLOWS OUT OF:		Direct	Roof r	Pond	Reserv	River	Lake	Ground	Aquifer	Ocean	Transp	Imported	Purification system	Laundry	Gray water recycling syster	Septic tank	
	Direct precipitation												0	0			0
	Roof run-off into storage tank												0	0			0
	Pond												0	0			0
	Reservoir												0	0			853
Source	River												0	0			0
	Lake												0	0			0
	Ground water												0	0			0
	Aquifer												0	0			0
	Ocean												0	0			0
	Transported as bottles imported into region												0	0			0
	Imported as raw water via pipes into region												0	0			0
	Purification system												0	0			0
	Well and pump												0	0			0
	Mixing system												0	0			0
	Water factory for region												0	0			0
Upstream	Water factory for neighbourhood												0	73			853
Converter	Water storage tank												0	0			0
	Regional water pumping station												0	0			0
	Desalination plant												0	0			0
	Clients for water												0	0			0
	Custom water input 1												0	0			0
	Laundry														0	0	73
	Personal hygiene														0	0	370
	Kitchen														0	0	50
	Toilets														0	0	352
Demand at	Drinking														0	0	0
Parcel	Irrigation														0	0	0
	Potted plants and pools														0	0	0
	Interior surface cleaning														0	0	4
	Exterior surface cleaning														0	0	0
	Vehicle cleaning														0	0	3
	Evaporative cooling														0	0	0
	Humidification														0	0	0
	Client demand														0	0	0
	Gray water recycling system															0	0
	Storage tank for pumping to truck or boat															0	0
	Sewage treatment plant regional															0	0
	Sewage treatment plant neighbourhood															0	853
Downstrea	Reclamation plant															0	0
Converter	Clients for water															0	0
	Custom water output 1															0	0
	Septic tank																0
	Detention pond																0
	Reed bed																0
	Infiltration trench																0
	Oil trap & drain																0
	Planter with infiltration system																0
	Constructed wetland																0
	Sluice & floodway																0
	Run-off onto surrounding hard surfaces																0
	Lake																0
Sink	River																0
	Run-off and infiltration into surrounding ground																0
	Aquifer recharge																0
	Ocean																0
	Evaporation into air																0
	Exported from region in pipes																0
	Exported from region in trucks																0
	Exported from region in pipes																0

Figure 107 An example for water flows at the parcel scale organised into a universal matrix that identifies all flows by quantity and direction, from source to sink

A parcel can be any discrete surface area: for example a park, a house on a private lot, a shopping mall a sewage treatment plant or a roadway. The single format for data structure allows for each parcel to demand flows, and to serve other parcels as a supply (or service) node. Thus the data structure allows for 'transformer parcels' that evolve over the long-term to become part of integrated and distributed infrastructure systems. The standardised data structure also helps to visualise the process of stock aggregation, as designers can move from a PLUS Sankey at the parcel or building scale, to a PLUS Sankey at other scales.

Sankey Examples

In *CitiesPLUS* the PLUS Sankey software was used to generate Sankeys for energy, material (organics only), and water. Figure 108 shows two

Sankey diagrams for Greater Vancouver's water system. The diagram on the left is the current system for water flows in Greater Vancouver; on the right is a system that has been proposed as a sustainable 100-year target. In each diagram the total water flow is proportional to the width of the noodles. Note that the total flow is largely unchanged over the 100-years, despite a population estimated to more than double. An explanation for the improved water efficiency is provided in the sub-models and pathway descriptions [*The Story behind the Water Pathway*, 2003, www.*CitiesPLUS*.ca]

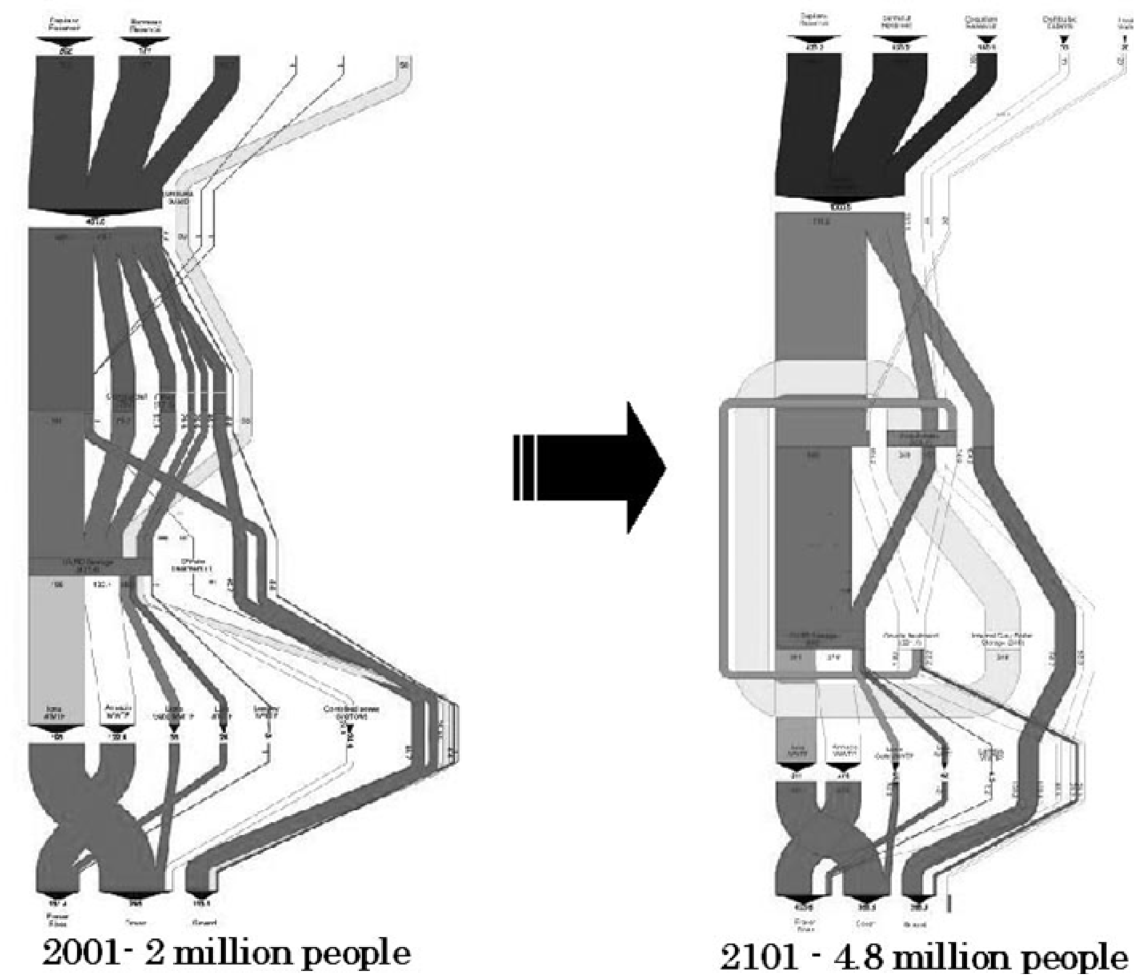

Figure 108 Sankey diagrams illustrate the differences in Greater Vancouver's municipal water system for the base year of 2001 and 100 year pathway to 2101 (m^3 per day)

In both the 2001 and 2101 Sankeys the resource flows are drawn from nature, treated, used, treated and returned to nature. The greater the efficiency of the system components, and the more looping (or use value) that is squeezed out of any resource flow, the fewer the resources that must be drawn from and released to the surrounding natural systems. The object then, is to expand the 'use value' in the centre of the diagram, and in so doing, shrink the top and bottom. In fact the ratio of the total use values to the total input values is one simple measurement of the eco-efficiency of a system.

The water flow for Vancouver in 2001 provides an interesting case study of a metabolic model if examined closely. At the top partition water flows from nature, beginning with rainwater and snow-melt that is captured and stored in three mountain reservoirs of similar capacity. Some very small increments are derived from wells and cisterns. In the second partition the water flows from reservoirs are combined at a regional treatment facility. Next the water flows to the third partition which includes everything from residential consumption (far left) to agricultural use and system leakages (far right).

The current once-through system next sends most of the wastewater to large treatment facilities in partition four where flows are augmented by substantial quantities of storm water delivered by combined sewers (coming from the top, far right). Water from irrigation, agricultural demand and leakage bypasses the treatment plants in partition four, as it goes straight into the ground in partition five. Treated water also ends up in partition five (back to nature) but instead of infiltrating into ground, a majority of treated water is received by the Pacific Ocean, with the remainder captured by the Fraser River. Thus this single diagram of water metabolism for Vancouver displays the entire life cycle flow for municipal water, by category and quantity. Additional flows can easily be added if desired to account for annual precipitation, run-off, and sub-surface flows, creating a complete water balance model for the regional watershed.

The Sankey for 2101 illustrates how the urban region will manage to sustain itself with more than twice the population, and without any increase in the water supply infrastructure. The same three reservoirs satisfy the water demand. Storm water overflows and leakage have been eliminated. Water reuse, efficiency and conservation have produced a factor 4 reduction in per capita water demand from the source. The reclamation and cascading of water is clearly visible on the Sankey as a looping of water flows.

Later versions of this software were used to visualize results of system designs for the international case studies at both parcel and urban scales. The author assisted each team with collecting data on reference parcels which were then used by the teams as archetypes during the aggregation process.[50] Figure 109 illustrates the energy system for the Jinze Town,

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[50] Data for the Jinze Town energy system was collected in part by the author during field trips to Jinze Town, and in part by graduate engineering students from Tongji University

Shanghai, in 2006 (transportation not included) based upon the aggregation of building archetypes; Figure 110 illustrates the preferred scenario for 2035, derived from the Systems Design Charrette.

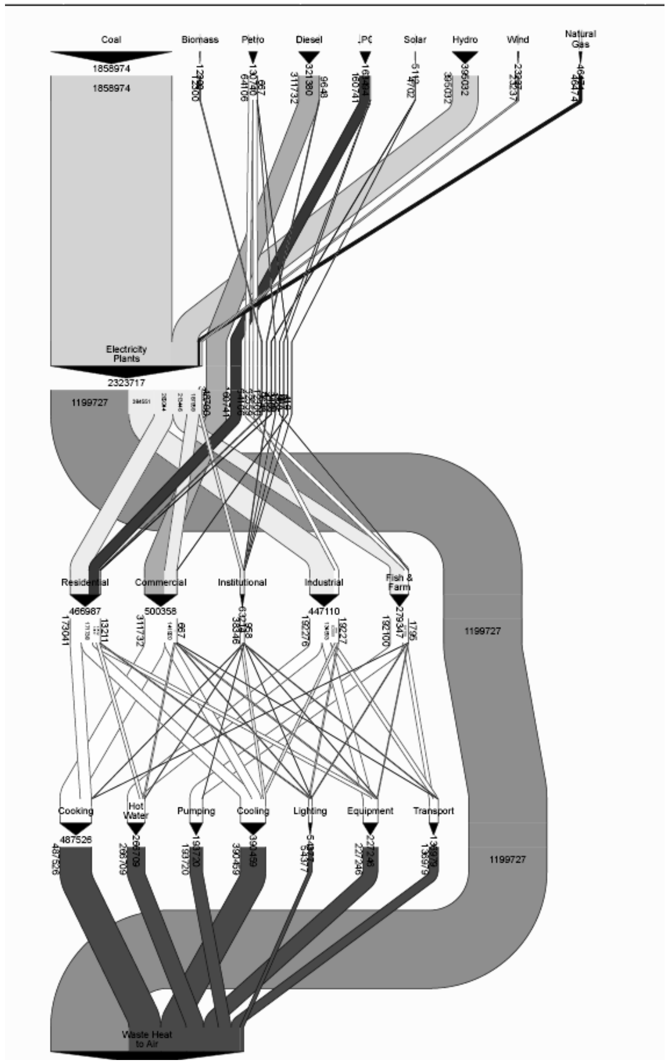

Figure 109 A Sankey diagram for energy in Jinze Town, Shanghai, base case 2006 (mega joules)

working with the Chinese Team. The values portrayed in the Sankey have not been verified in all instances.

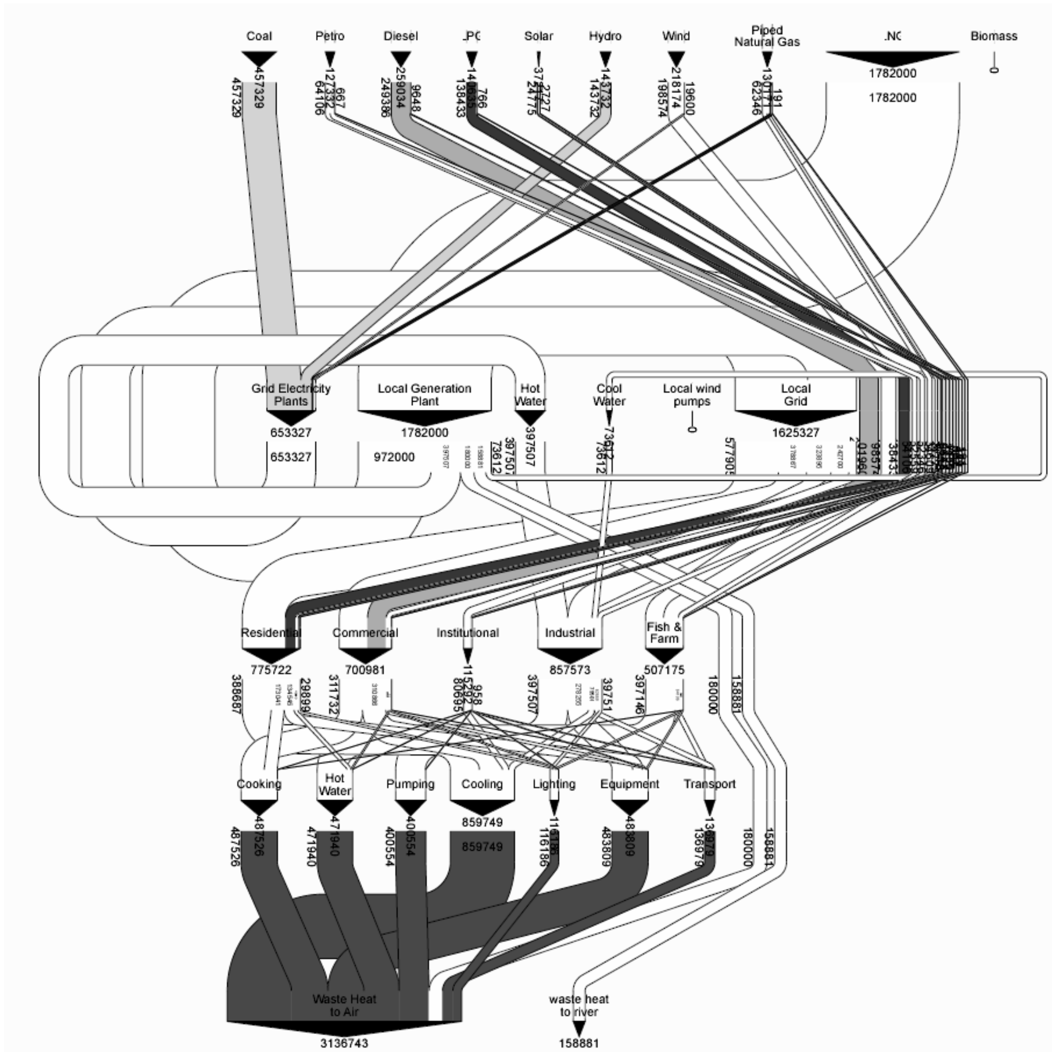

Figure 110 Proposed Energy System for Bridging to the Future in Jinze Town, 2035

As a result of compiling and comparing such a diversity of Sankeys it was possible to identify patterns that may help to categorise the resource flows for different types of built environments. Figure 111 provides an example of such a pattern language for resource flows at the parcel scale. The same patterns would also be recognizable at the regional scale.

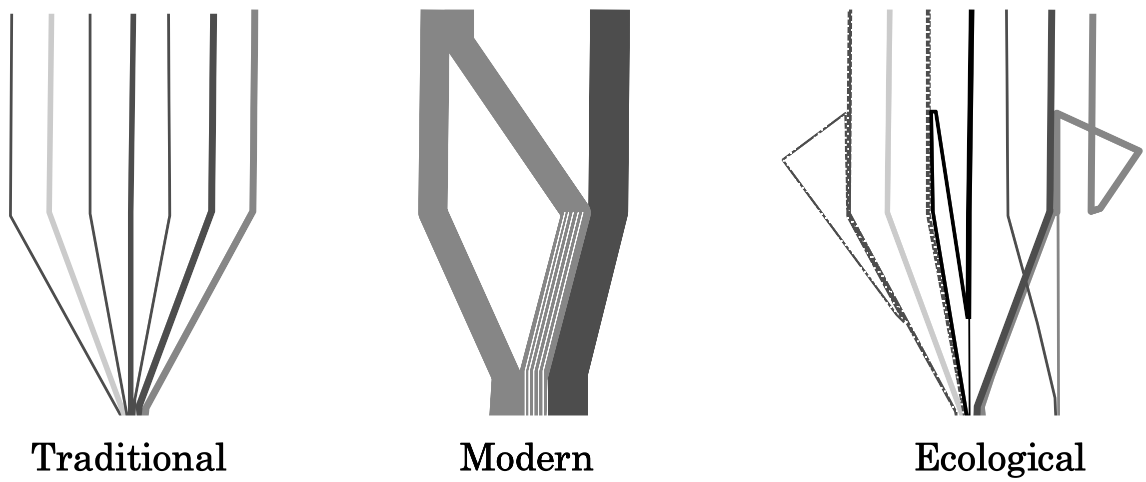

Figure 111 A Sankey pattern language shows the possible evolution in technology for mass and energy flow at the parcel and regional scales

The first pattern, *Traditional*, is typical of the oldest and also the poorest houses in India and China. *Traditional* is based upon data collected on a 100-year old traditional home in Jinze Town, Shanghai. Total resource use is relatively small, but the mix of primary resources is very complex. Each fuel is carefully matched to the requirements of the end use, for optimum efficiency and cost. The *Traditional* home may be poor and old, but the energy systems are relatively sophisticated. Even the informal home (urban slum) audited in Goa, India revealed a complex mix of fuels, including LPG, electricity, wood, kerosene, solar, gasoline, and coconut husks (used for water heating).

The second pattern, *Modern*, is typical of recent, tract-built houses in urban suburbs world-wide. Modern is based upon a single family home in a new gated community on the outskirts of Jinze Town, Shanghai. Total resource use is almost an order of magnitude higher than traditional homes, even though family size had dropped by 60% or more. The primary mix of energies is simple since almost all energy demands are coal-generated grid electricity, with the exception of cooking and transportation.

The third pattern, *Ecological*, is typical of the 30-year pathways. The Resource load is mid-way between the *Traditional* and *Modern.* It combines the complexity of the *Traditional* with the convenience of the *Modern.* Some energy re-cycling (cascading) increased the service value of the flows, which increases the total flow at the demand partition relative to the other source and sink. Ecological is based upon a hypothetical home connected to the proposed 2035 Jinze Town energy systems. The primary mix is even more complex than Traditional, due to the use of hybrid systems with intelligent controls, and the greater diversity offered by networked local energy services. However the greatest difference may be the increased flexibility and adaptability of the *Ecological* home.

Sankey Standard Formats

For presentation purposes, all of the PLUS Sankeys have been standardised for vertical flows, with inputs at the top, flowing (as with gravity) to outputs at the bottom. For readability, all of the PLUS Sankeys developed for this thesis were limited to a maximum of five partitions: SOURCES, CONVERTERS, DEMANDS, RECONVERTERS, and SINKS. The edges connecting the nodes at each partition have been displayed using curved lines. The curves are intended to be "suggestive of real systems that transmit flows" [MANSFIELD 04] as opposed to straight lines which tend to imply simple connectivity.

The uppermost and lowermost partitions include natural sources and sinks, as well as any off-site infrastructure systems that 'import' or 'export' substances. At the regional scale, most products and resource flows tend ot be generated within the boundaries shown, and thus the Sankey illustrates the complete metabolism – or 'nature to nature' flows. Energy Sankeys can be displayed in an identical format to MFA Sankeys. CONVERTERS and RECONVERTERS are general terms for the on-site urban infrastructure or appliances that store, convert, regulate, separate, process or recycle any flow. A CONVERTER is on-site and 'upstream of all demands, while a RECONVERTER is on-site and downstream of at least one demand.

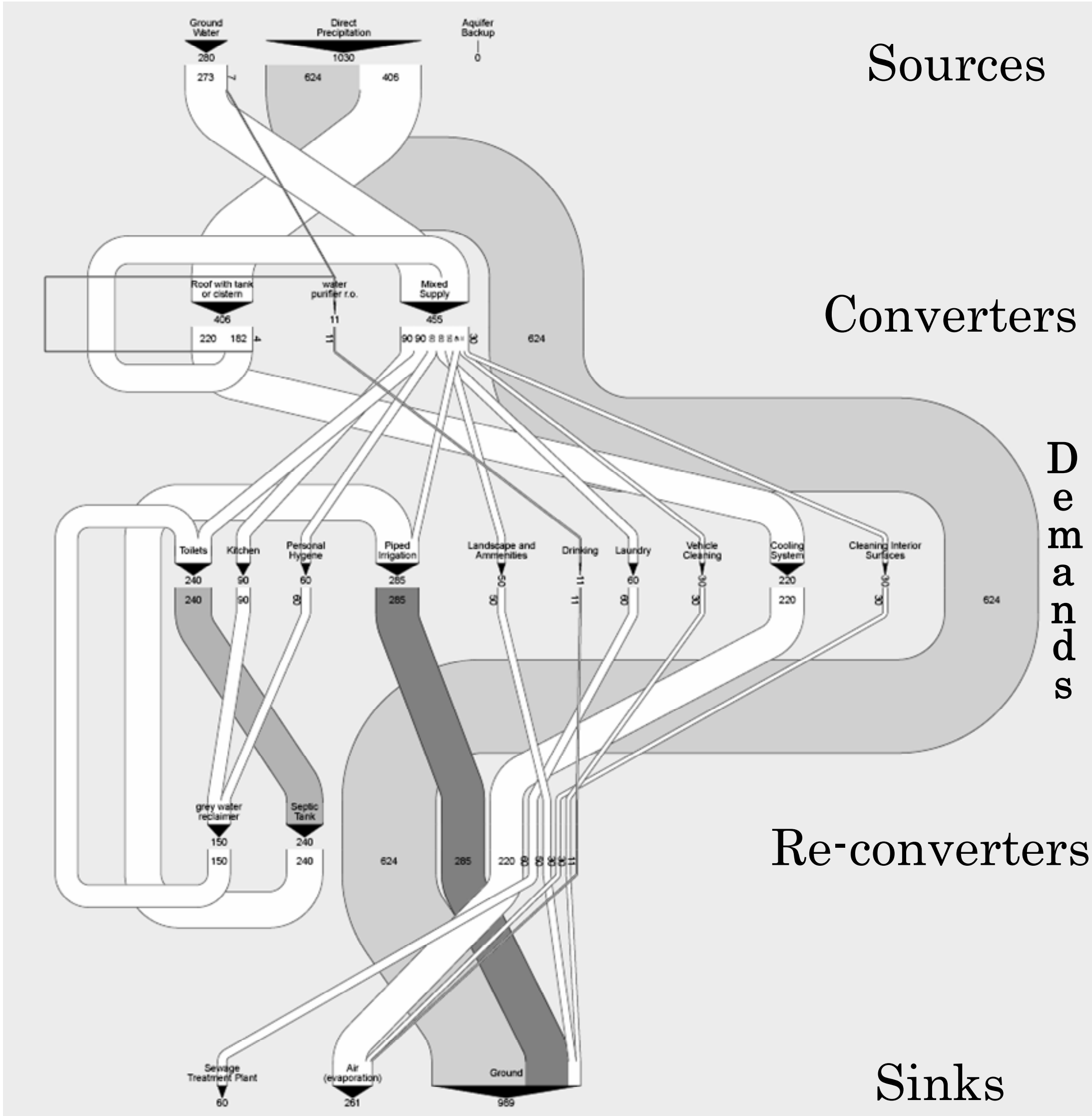

Figure 112 An example of a PLUS Sankey diagram that uses the five standard partitions to visualise water flow for a new 'green' single family detached home in New Delhi, India

At the parcel scale, the regional infrastructure nodes are off-site and thus move to the 'SOURCE' partition, along with any direct use of natural resources on-site. At the aggregated spatial scales, more of the urban infrastructure typically will be included as on-site, and consequently is displayed as nodes in the CONVERTER or RECONVERTER partitions. However aggregate scaling means that the appliances at the parcel scale are no longer displayed and instead become bundled as factors influencing the quantity of flows into and out of each demand node.

PLUS Sankeys at the parcel scale can be directly summed to create a PLUS Sankey for the region. The loss of information at the parcel scale is traded for a more ordered diagram at the regional scale. In order to permit such an aggregation approach the database for the urban model needs to identify geographically reference all conversion systems, so that it is clear what is on-site and off-site. Thus the database stores information that allows for all flow to be connected within the scale of the area under study. If detailed dynamics are felt to be more important than readability, it is possible to present all Sankeys with 7 partitions: SOURCES; REGIONAL CONVERTERS; PARCEL CONVERTERS; DEMANDS; PARCEL RECONVERTERS; REGIONAL RECONVERTERS; and SINKS.

Regardless of how many partitions are displayed, the Sankey structure dictates a database structure based upon the urban metabolism with rigorously balanced flows. By generating the system flows from the demand partition of each parcel, the metabolism is actually an aggregation of parcels. Thus the PLUS Sankey is a hybrid analysis, combining the input-output dynamics for the entire physical system – a top-down approach - with a demand-driven model that begins with the smallest element measured, in this case the parcel, and then aggregates to the entire system –a bottom-up method. However because the demand partition lies at the centre of a metabolic model, the hybrid is not so much a combination of top-down and bottom-up methods, but rather 'outside-in' and 'inside-out'.

Mapped Sankeys

PLUS Sankeys reflect the spatial characteristics of urban systems to the extent that the spatial boundaries determine which nodes are included at each partition. However additional spatial information can also be included as an alternative format for the same information. The alternative format involves geo-referencing the nodes and parcels, and mapping the flows using edges and arrows. This secondary format represents a return to the kind of information shown on the Minout's Sankey for the Napoleon's armies marching to Moscow. To create mapped Sankeys, it is necessary to map the connections and flows using a GIS and database application such as Community Viz. This is relatively straightforward, since the database includes spatial coordinates for all the parcels and the nodes for each partition. Nodes that are not located on the map, such as off-site infrastructure, can be located at the perimeter of the mapped area, so they are visible, but essentially external to the scale shown. The result is a Sankey map, in which information content is greatly increased. Basically the nodes in each partition are transformed from rows in a chart to actual locations on a map. The challenge is to avoid the appearance of a plate of spaghetti (complexity) when introducing the additional geographical information. To this end the vectors and line (edges) between nodes on the map must be 'forced' by the software to follow the major roadways.

Transposing flows onto a map is useful as a way of understanding the 'catchment areas' or service territories for particular infrastructure systems, and in particular for recognising the efficiency of transmission systems, and distribution patterns such as the degree of resource sharing at the local scale. The result of mapping a PLUS Sankey is a network diagram for the proposed scenario, showing flow qualities and quantities, connections and directions of flows between nodes, and the sequencing of flows through the urban metabolism. If infrastructure evolves into more distributed and self-organising networks, then such Sankey formats may become especially useful during design exercises.

Temporal Sankeys

Sankey diagrams are period-oriented, in the same way as corporate financial accounting. The length of the period can vary depending upon the decision-making. If flows are averaged over the year, they provide a good benchmark for tracking efficiency and for understanding ecological footprints. However annual flows fail to reveal the seasonal and daily peaks, which impact costs, and are often a key determinant in system design. Ratio of peak to average can range from 2 to 10 for such flows as energy, water and people in large urban centres. A Sankey based upon peak hour for energy, or daily flows during the peak month for water, provides an especially important perspective from which to evaluate a system design, especially when dealing with impacts of urban growth alternative connectivity for supply systems.

Use of the PLUS Sankeys has revealed the benefits of augmenting the urban database and software, so as to allow for temporal Sankeys that shrink and swell (animated graphics), and that can be 'fired' and synchronized using a time scale or clock/calendar in the legend. Such temporal or moving Sankeys would allow for a more dynamic system representation, and may ultimately be necessary for selecting the most sustainable system designs. For example, if water demand for toilets is satisfied from a rainwater cistern filled by roof drainage, what happens when the cistern is empty during peak demand events or during dry months? If the cistern is controlled by a float valve, does the back up water come from grey water reclaimers, and if these are insufficient from municipal piped water?

The same kinds of sequenced pathways can occur in networked systems at the neighbourhood and regional scale, and for flows of energy, materials and even people. If animated Sankey diagrams can be directed with Boolean equations at each node and edge, they can display dynamics of systems over time. In essence they begin to function more like a Coloured Petri Net, [JENSEN 97[i]] in which the 'tokens' are the energy or material flows, and the nodes are transition specifications (sub models, Boolean statements and algorithms) that trigger new edges and directions in asynchronous parallel pathways.

"One advantage of the period-oriented material flow networks is the possibility to integrate more complex models using non-liner functions." [MOELLER02] Basically the discrete simulation models – such as energy demand values for a building – function as transition specification in the network diagram, and create the data values underlying the edges entering and exiting a particular node. The concept of transition specifications for material and energy flow analysis is "a practical enhancing of the System Dynamics approach." [MOELLER 02]

By introducing a Sankey diagram of built systems at the Scoping layer of the SEEIM framework, it becomes possible to use Sankeys to describe systems at all other layers. Boundary confusions are less likely since the Sankeys provide a systems context for all analysis in all scenarios. In *CitiesPLUS* the Sankeys were initially used to describe the existing systems (Scoping). However their greatest value emerged as a tool for positing new scenarios, and comparing alternative pathways. The International Teams in Bridging to the Future also used Sankeys principally to define and compare scenarios. [*Summary Presentations*, 2006, Results in www.bridgingtothefuture.org].

As a scenario planning tool, PLUS Sankeys may still suffer from excess complexity. The format requires a clear, standardised and stable spatial boundary for the urban systems, and this can be difficult for reasons outlined in Chapter 4. At local and region scales the PLUS Sankey will typically fail to track all flows from nature to nature; thus to balance the metabolic model it is necessary to allocate substantial flows to dead-end categories like import, export and storage. Despite these methodological difficulties, PLUS Sankeys appear to simplify the design process both in terms of communications, and environmental accounting. They also appear to reinforce the creative, whole-system thinking that is fundamental to the ecological design methods discussed in Chapter 4.

11.4 Methods for Exploring Resiliency

A challenge that confronts system design teams during the Exploring level is orchestrating a response to the many potential impacts of future forces on each of the urban sub-systems. A method is required for dissecting this problem. What are the hazards, threats and vulnerabilities? Can the negative impacts be assessed and aggregated? What can be done to reduce vulnerabilities for each system and each threat? And what design strategies are likely to be most effective across the full range of systems and a representative range of threats?

To answer these questions in *CitiesPLUS*, it was decided to develop two new complementary decision analysis tools: Influence Intervention Diagrams (IID) and Urban Shock Scenarios (USS).

11.4.1 Influence Intervention Diagrams

Influence diagrams appeared especially well suited to representing the spreading, logical tree of influences and relationships between future forces, the dynamics of an urban system and the impacts on groups of concern. For this purpose, the icons used in the *CitiesPLUS* diagrams are used to clarify the levels of influence. The influence chain begins with a *primary driver* (e.g. rising incomes), followed by the various effects or *manifestations* within the urban system at the regional scale (e.g. aging population); followed by the *intermediate effects* that form part of a chain of influence (e.g. increased use of heath care systems, leading to more staffing and use of equipment). Eventually the chain completes with *impacts* of concern to sustainability, expressed in terms of costs or benefits in three categories: economic (higher taxes for health care); social (longer wait time for care); and environmental (increased pharmaceuticals in the waste water).

An example influence diagram is shown in Figure 113, along with a legend for the icons. This example is for one *primary driver*: climate change. The climate change example was used in *CitiesPLUS* to cope with the complexity of possible impacts when assessing impacts in accordance with the IPCC methods[51]. The example shown is for one urban system: buildings, although similar diagrams were completed for all of the relevant urban systems categorized in the *CitiesPLUS* scope.

Beginning at the top left of the diagram, human activity combines with natural cycles to contribute to increasing CO2 concentrations in the atmosphere. This in turn leads to climate change which manifests in the Greater Vancouver region as a parallel series of perturbations including warmer temperatures in the summer and winter, wetter winters, and sea level rise. These are a subset of the climate changes predicted for Greater Vancouver by the climate change models used in British Columbia, and used by the IPCC, described in Chapter 5.

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[51] The IPCC outlines an approach to climate change adaptation based on sensitivity, adaptive capacity, and vulnerability. The IPPC defines these terms as follows. **Sensitivity** is the degree to which a system is affected either adversely or beneficially by climate related stimuli. The effect might be direct or indirect. **Adaptive capacity** is the ability of a system to adjust to climate change to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. **Vulnerability** is the degree to which a system is susceptible to, or unable to cope with adverse effects of climate change. Vulnerability is a function of climatic variation, its sensitivity and its adaptive capacity.

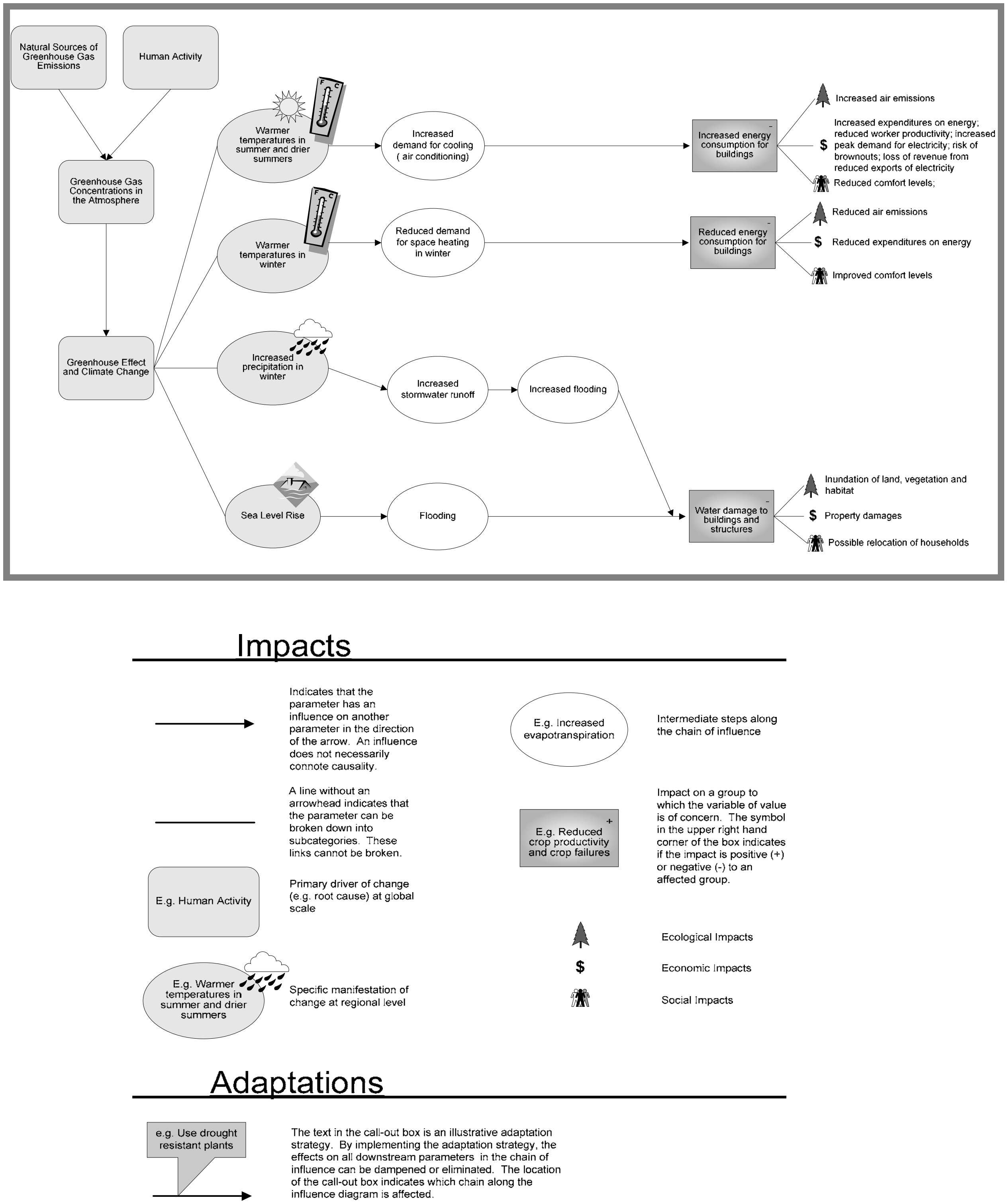

Figure 113 An Influence Diagram developed for *CitiesPLUS* shows how one force: Climate Change, may impact one urban system: Buildings

Each manifestation can lead to a cascading and branching series of intermediate effects, and ultimately to a tally of costs and benefits. The visualization of these impact chains is a simple application of influence diagrams. However with just a dozen pages of similar influence diagrams it becomes possible to quickly orient design teams to the key vulnerabilities of urban systems to the effects of climate change.

The *CitiesPLUS* tool became still more effective when used to identify adaptive design solutions. The solutions were expressed as *interventions* in the influence chain, as shown in Figure 114. Hence the tool becomes an *Influence Intervention Diagram*. Each call-box on the diagram describes a strategy or action that may help to mitigate or eliminate a negative influence chain, at the location marked. In this example 14 different intervention strategies are displayed for reducing vulnerability of the urban building stock to the effects of climate change. Because of the branching nature of these diagrams, and the predominance of negative impacts, the ideal approach is to try to 'break' the influence chains by locating interventions as close to the *primary driver* as possible (i.e. far to the left).

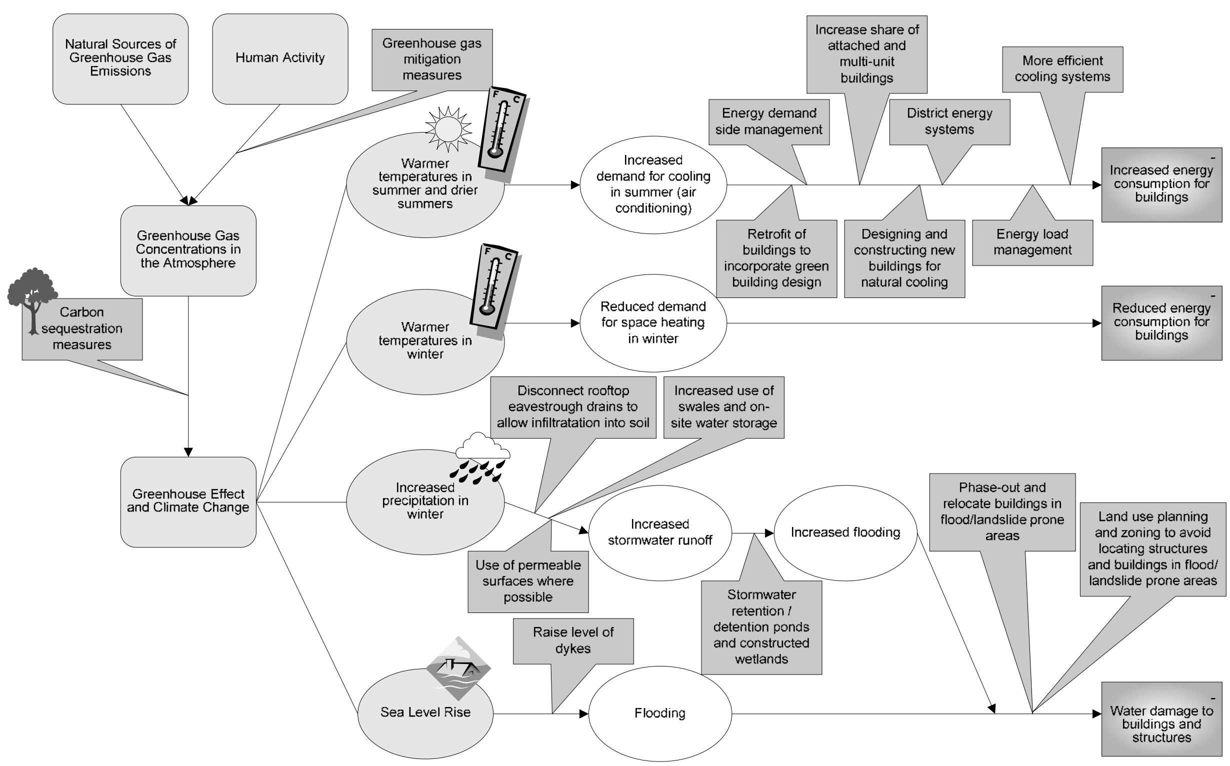

Figure 114 By inserting interventions the Influence Diagram becomes a trans-disciplinary tool for strategic planning

Once the influence diagrams have been used to identify a full range of adaptive solutions, the diagrams can be cross-referenced and used for selecting synergistic strategies that appear to significantly reduce vulnerabilities across multiple urban systems. Displaying all categories of impacts, both negative and positive, is added effort and complexity, but provides a more balanced view and, presumably, a more effective assessment of trade-offs for decision-makers. In this way the *Influence Intervention Diagrams* provide a rational, comprehensive process for group learning about adaptation and adaptive design.

To properly evaluate the IIDs would require a more inclusive process than was possible with the *CitiesPLUS* case study. Based upon the case study, it appears to be a challenge to develop the influence chains and impact summaries without significant input from experts in many disciplines. With more time for research, it may have been worthwhile to explore the use of focus group sessions for this purpose. Similarly a workshop or other participatory process may have helped sub-sets of sub-teams to gather and explore a full range of adaptation strategies for each combination of threats and systems.

Following the final *CitiesPLUS* submission the author was contacted by groups in the USA and Canada who requested the new IID 'software' to use in their own work. Unfortunately the tool had been a custom application, with no effort given to future transferability. One of these groups subsequently used the tool to structure a creative process for experts, using hand-drawn flip charts to display their own IIDs.[52]

Another short-fall of the IID tool as used in *CitiesPLUS* was that the influence diagrams did not include magnitude, quantification or aggregation of impacts, as would occur, for example, with a more evolved process such as Life Cycle Assessments. Nor was there a rigorous process for prioritization of the most effective (synergistic) intervention strategies.

Finally the tool suffers from a highly structured, reductionist approach. Because so many urban systems can be impacted by threats like climate change the IID process is likely to overwhelm the resources available to most design teams. An alternative technique was also required, based upon a more narrative process, and a more cyclical view of time.

11.4.2 Big Urban Shock Testing

As an alternative to the IID tool a *CitiesPLUS* scenario tool was created, and referred to as Big Urban Shock Testing! (BUST!). The tool is based upon a narrative process, and the assumption that big disasters will occur

[52] Personal conversations with Jennifer Penney, Senior Researcher, Climate Change Adaptation, Clean Air Partnership 75 Elizabeth Street, Toronto, ON M5G 1P4

upon occasion, with catastrophic impacts. This approach thus helps to introduce disaster preparedness and shock resistance into the design criteria, and is more compatible with a cyclical view of time.

Archetypal disasters have been suggested by a number of writers as a way to explain historical events. [DIAMOND 05] [WRIGHT 04] A failure of cities, or of whole civilizations, can be categorized using such typologies. However the categories used for such historical analysis are not restricted to external shocks, and instead include the internal institutional failures and also the progressive demise of ecological support systems. On the other hand, most of the literature on cities and shocks has exclusively focused on natural disasters, with only passing mention of other types of sudden change to urban systems. Thus a new categorization of disasters was needed for the *CitiesPLUS* BUST! scenarios.

Four categories of disaster archetypes were defined: natural disaster; hiccup; global disruption; and sudden obsolescence. These archetypes were then used in workshops, where separate break-out groups were given the task of developing a 'worst-case' scenario for each category. The archetype was fleshed out by means of a storyline that described an event, or series of events, based upon the local situation.

Natural disasters are self-explanatory, although the actual forces vary by location. In Netherlands, a natural disaster scenario might be a flood or an ice storm; for India a drought or a tsunami, for Vancouver an earthquake or forest fire, for Shanghai a typhoon or a plague. In each case, a plausible scenario is created for each the archetypes and then used as a proxy for all types of natural disaster.

Hiccup refers to a sudden, temporary loss of critical infrastructure services. Almost all urban areas experience this type of disaster from time to time, although nobody designs for it. For example, consider hiccup created by the cascading loss of power on the eastern seaboard of North America for 3 days in the winter of 2004.

A global disruption refers to any human-induced event occurring outside the region that might undermine the viability of systems, and the security of residents. For Greater Vancouver this might entail a closing of the border with the USA; for Goa a mass migration of peoples from other states where systems have collapsed; for Netherlands an international boycott of exports; for Shanghai a war with Taiwan.

Sudden obsolescence refers to an unexpected reduction in the need for certain goods or services. For example, changes to information technology may quickly reduce congestion from peak-hour commuting, and thus make the large scale transportation routes and parking areas obsolete. Changes to weather and water availability may lead to the disintegration of large urban areas, and a corresponding drop in demand for services within the traditional urban boundaries. Changes to regulations or trading agreements may make fossil fuels unavailable for import, and thus require that whole systems be permanently converted or replaced.

Once each group fleshed-out the archetype with plausible details for the locality, their task is to tell the story (scenario) from a position in the long-term future. The scenario would include a description of the event (what, when, where, why) and, more importantly, a description of how the urban design exercises begun in 2006 had helped to prepare the region for the shock and allowed the urban systems to rapidly recover to a full state of health without excessive costs.

BUST serves as a brainstorming tool for promoting resiliency by design. As each team presented its disaster scenario it was possible to recognise a repetition of the same shock-resistant design strategies: compartmentalisation and local self-reliance, contingency planning and education, a diverse resource base, and fewer interdependencies between the critical infrastructure systems. Some of the strategies for one type of shock were easily adopted for other types of shocks. For example, one multi-purpose strategy was to use a decommissioned military ship as a floating hospital, electricity plant and quarantine centre, so that all coastal cities in the region could install plug-ins for connecting to this same mobile infrastructure if necessary. It also became clear that many of the design strategies that improve efficiency of resource use, such as distributed generation and treatment, also serve to enhance resiliency. For example, the investment in demand reduction through more efficient building design and more local looping of waste resources appears to create communities that are inherently more shock resistant.

As part of follow-up research to *CitiesPLUS* it might be possible to integrate the IID and the BUST tools into a new process for resiliency by design. Such a process would allow for many groups to continuously engage in a gaming activity wherein the urban region is threatened by a representative number of threats comprised of both driving forces and unexpected shocks. This type of process might be a mechanism for handling the complexity and evolution of the 'all-threats' analysis referred to in Chapter 5.

Figure 115 includes a vision statement I prepared as an outgrowth of the *CitiesPLUS* research on Security Systems. Working with the emergency planners for the Greater Vancouver municipalities, and the energy utilities, the author crafted a new vision with a more pro-active definition of disaster preparedness (see highlighted text in figure).

Vision Statement for a Disaster Resilient Region

- *Greater Vancouver is a disaster resilient region. Disaster resiliency means that everyone in the region accepts full responsibility for emergency planning and preparedness. Responsibility begins with individuals, who must prepare to look after their own needs, and the needs of their family, employer and neighbourhood. Where an individual's capacity is insufficient, then the responsibility cascades to include private and public organizations, moving from local to regional scale. This expanding circle of responsibility ensures that resources are efficiently organised and shared, such that capacity for responding to disaster is never overwhelmed, and nobody is left alone. Mutual aid agreements within and between all sectors foster good will and cooperation, and establish clear lines of authority, even as conditions change.*
- *Disaster resiliency also means societal learning. All parts of society are engaged in training and practice for emergency response and recovery. Past successes, near misses and failures – both here in our region and elsewhere - are regularly evaluated and the conclusions shared so that everyone can continuously learn, improve and adapt. Special attention is given to developing a 'culture' of resiliency, by educating such key groups as school children, businesses, and voluntary responders. This culture of resiliency keeps alive the traditions of the region, especially the self-reliance and community-mindedness that sustained our first nations and our pioneers through difficult times.*
- ***Disaster resiliency means proactive emergency management. On-going collaborative research among private and public organizations provides knowledge and foresight on all threats. Information is shared so that decision-makers can understand what patterns and trends are likely to threaten the region's ability to sustain a high quality of life. Disaster resiliency is a crosscutting theme integrated into land use planning, building design and all infrastructure systems. Different disciplines work together to find elegant solutions for achieving both disaster resiliency and the region's goal of economic, social and environmental sustainability. Emergency management systems are adaptable, accommodating rapidly changing perspectives on what might constitute threats and vulnerabilities.***

S. Moffatt, on behalf of Greater Vancouver's Regional Emergency Planning Committee, October, 2003

Figure 115 A draft new vision statement that attempts to incorporate a new paradigm for urban resiliency

The on-going evaluation of threats, vulnerabilities and risks at the urban scale, and the inclusion of system designers and planners in the emergency planning, represents a significant institutional transformation along the lines described in Chapter 5. The net result might be a localised 'intelligence service' - a public/private network connecting each urban system, with a mandate to identify and respond to emerging security concerns. In this context tools like BUST and IID will be needed to reduce complexity and facilitate collaborative design and decision-making.

The use of these tools contributed to a series of priority recommendations for new infrastructure and policy in Greater Vancouver. In the example of Climate Change, these recommendations included a revised flood protection plan, changes to estuary management, dyke controls, potable water system redesign, upgraded engineering specifications for storm sewers and more. Even in their rather crude form the IID and BUST tools appear help with the complexity of climate change adaptation, and presumably the tools could be to be transferred to other regions. They do not require that researchers obtain detailed prior knowledge of all future forces and associated impacts; they engage decision-makers and stakeholders in a 'charrette' style discussion about threats, vulnerabilities, risk assessment and mitigation; they include both urban design solutions and the responsive capacity of institutions; and they provide a basis for quantitative (probabilistic) assessment of adaptation options for defining cost/benefits of adaptation.

11.5 Methods for Implementation

In broad terms, Implementation refers to the process of translating long-term pathways into appropriate short-term actions. In *CitiesPLUS*, the 18 sub-systems and 200+ goals and targets created a tremendous range of possible strategies, each of which could be implemented in different ways, in different locations. The complexity of interactions between the choices further complicates the design exercise.

From this perspective, Implementation can benefit from a selection process so that limited resources can be properly focused and leveraged. One way to focus is to identify trends that are in the wrong direction – relative to the goals and targets - and then designing interventions to help the region 'turn corners' that otherwise will be missed. Briton Harris, writing in *Decision-Making in Urban Planning* [ROBINSON 78] argues that this 'trend correction' is the essence of all urban planning. "Planning is anticipatory decision-making, and if things were not apt to go wrong without it, it would not be needed…. The anticipatory role is forced upon it; we feel the cold breath of disaster behind us."

At the scale of an urban region the possibilities for intervention are certain to exceed the available resources, and some kind of prioritisation process is required. Are there strategies that are especially effective because they help to achieve multiple targets simultaneously? What are the barriers to success, and is the IDCD team composition appropriate for influencing such barriers? How can limited resources be used to leverage change across the region? Are some actions especially timely, or especially suited to local skills and conditions?

A tool for answering such questions was developed and applied within *CitiesPLUS*. Referred to as *Catalyst Intervention*, the tool assisted the team in assessing change management options, and in selecting a short list of interventions with high potential.

11.5.1 Catalyst Intervention

A term first used by chemists, 'catalyst' refers to a substance that is used to accelerate the rate of a chemical reaction already underway, without modifying the basis elements of the solution. The concept of a catalyst is often used as a metaphor for managing change in any system. For urban systems, the metaphor has a number of useful messages for designers. Catalysts affect changes that are already underway, at least to some small extent, and thus the design team must seek out the progressive examples within the region – the acu-points described by the Mishima Team - and build upon these successes. The rate of acceleration must be controlled, so as not to exceed the limits of the 'solution space'; too much catalyzing can be as problematic as too little. The basic elements are to be left intact, which can suggest that the people, culture and the ecology of the place are to be protected over the long-term. Defined in this way, catalyst may be an especially suitable term for guiding the implementation layer of the design process.

In *CitiesPLUS* the term catalyst was used to define specific categories of strategies, projects and policies. The approach began by identifying 'meta' themes emerging from the work on pathways by the various sub-teams. The identification process involved mapping and ranking of options by the core team of researchers, followed by a more inclusive workshop involving many of the experts and partners for a half-day session on reducing the themes to a manageable number (8 to 10). This was a difficult and complex process for which no special methods or tools emerged. The feedback from the larger workshop was not especially helpful since the groups preferred to bundle themes together (more complexity) rather than let go of any theme.

Eventually a discrete set of 8 key themes or 'Catalyst Strategies' emerged as a concise and public statement of Greater Vancouver's long-term system design (Figure 116). In making the selections, value was placed upon strategies that appeared to embody key paradigm changes, and had relevance to goals and pathways for many systems. Other criteria used for ranking strategies included their potential for inspiring design practice, and for countering undesirable trends.

'Catalyst Strategies' can be used to counteract those trends that conflict with end-state goals, to fill gaps in current practice and awareness, to avoid disasters and to take advantage of positive synergies. Part of the challenge is to find strategies that are general enough to embody a large number of actions – and yet specific and different enough to move thinking beyond motherhood statements. Ideally the strategies are described in language that is simple but powerful, since the role of these strategies is to both coordinate innovations by many designers, and to inspire participation.

The final set of strategies became a central element of the *CitiesPLUS* 100-year design submission, including detailed descriptions and many illustrations. [*A Sustainable Urban System*, 2003, www.citiesPLUS.ca] In the process, the strategic approach gave rise to a suite of analytical and visualisation tools referred to as the Catalyst Intervention Toolkit.

Figure 116 A set of cross-cutting and 'inspirational' strategies provides one way to manage complexity; the 8 CitiesPLUS themes were used to guide interventions across all the urban systems

Catalyst Intervention Toolkit

The Catalyst Intervention toolkit is a four step process supported by visualization software. A functional version of the tool is included on a CD and on the web, as an integral part of the *CitiesPLUS* submission. The four steps include Catalyst Practices, a Catalyst Gallery, a Policy Matrix and Catalyst Projects.

The first step is a *Dress-up Sketch*, designed to overview the full set of possible best practices related to each strategy. To assist in this process the author developed interactive visualization software that allowed each sub-system team to 'dress-up' a skeletal isometric sketch of the urban area, at the scale of individual parcels and neighbourhoods. Basic strategies were then illustrated and layered, to allow for one-click changes of information: switching from one sub-system to another, and one physical scale to another. An example is shown in Figure 117. This interactive overview of practices provided a simple communications tool for dialogue on how to better integrate urban systems, and for identification of synergies. The tool can be used to structure a workshop or a discussion, or to support a round-robin of meetings between sub-systems as they join to identify mutually beneficial implementation measures.

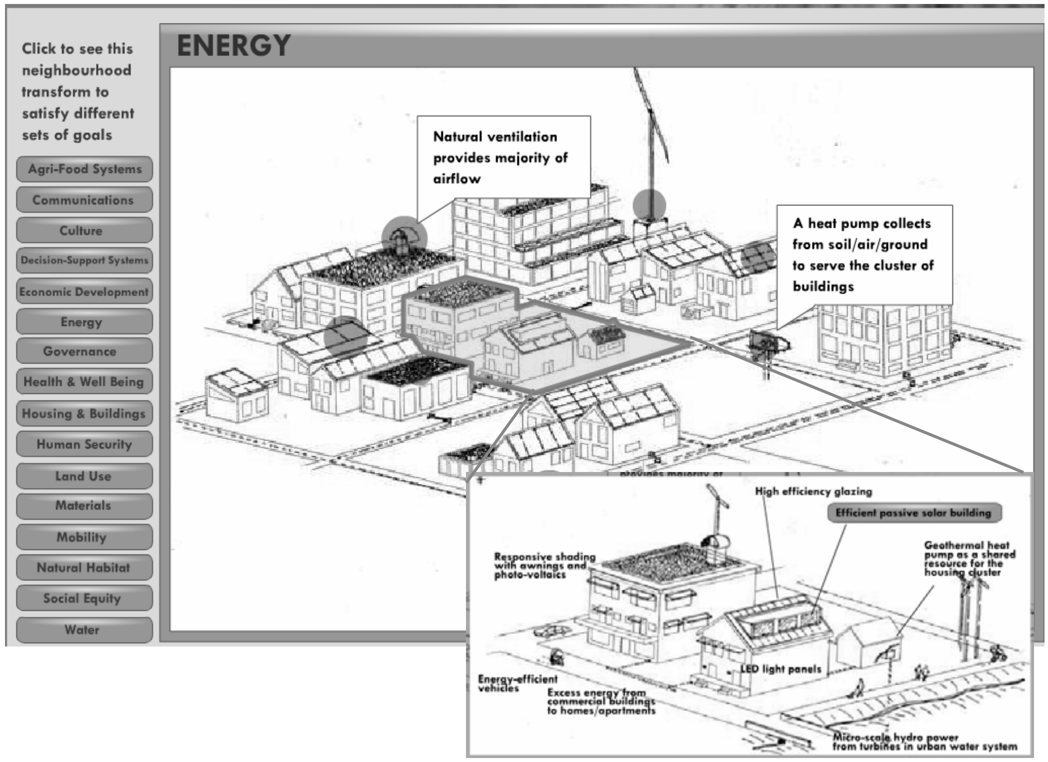

Figure 117 An interactive overview of possible practices for implementing catalyst strategies, organised to 'dress-up' each sub-system at the scale of a typical parcel or neighbourhood

The second step is a *Catalyst Gallery*. The tool uses 'artistic' renderings of example applications to provide site-specific visualisations on how each catalyst strategy might guide interventions. To assist further with communicating Catalyst Strategies, were assembled into a Catalyst Gallery. The Catalyst Gallery of Strategies allows users to select scales and time horizons, and to see examples of the strategies displayed on isometric drawings, maps and pop-up drawings. Figure 118 provides an example of the Catalyst Gallery of Strategies.

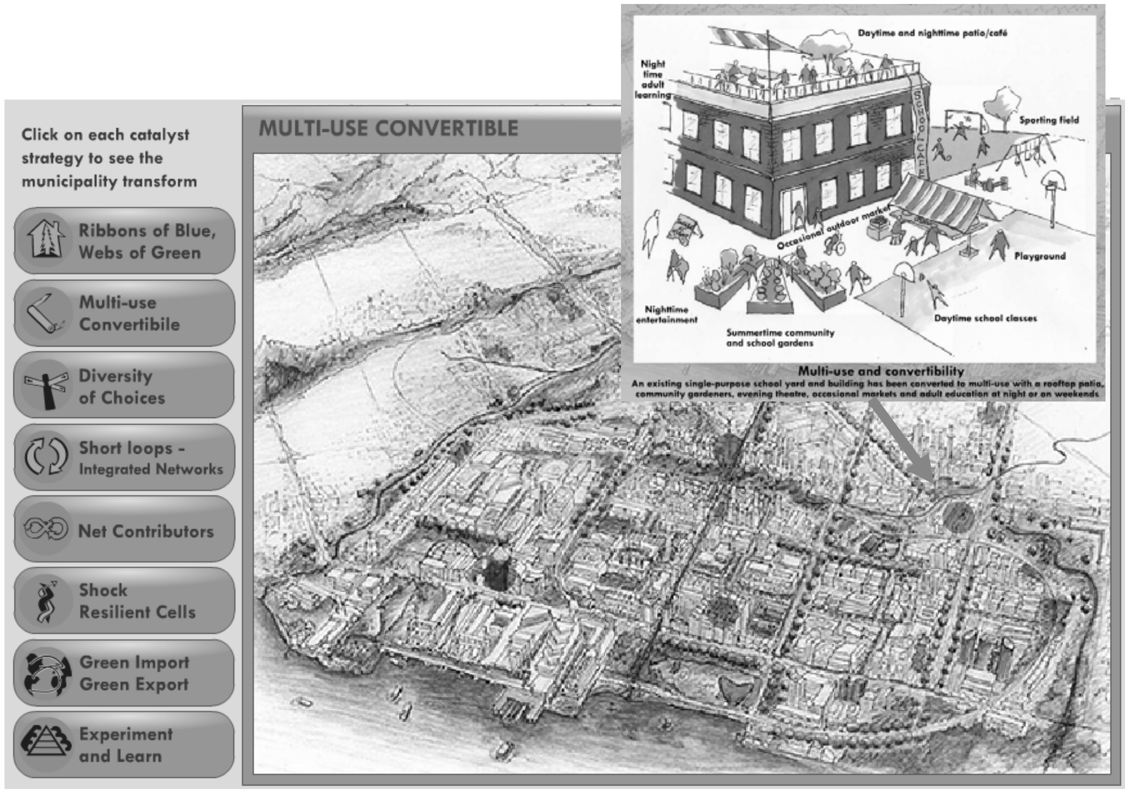

Figure 118 A Catalyst Gallery of Strategies provides a means of communicating the types of changes required: each strategy can be explored through pop-up images and hyperlinks that are situated on the landscape at different times in the future

The third step is a *Policy Matrix* for each Catalyst Strategy. The matrix is a tool for change management, and not communications. Its purpose is to provide guidance to each actor on all possible policy initiatives. Figure 119 is an example Policy Matrix for the Catalyst Strategy "*Create Shock Resistant Cells*". The list of actors is intended to reflect the four quadrants of the collaborative, including government (national, provincial, regional and local), the private sector (corporations and utilities) and the civil and academic sectors. The policy tools include planning and design initiatives, research and demonstration, education and inspiration, legislation and enforcement, financial instruments and universal actions.

The Policy Matrix is a tool for strategic thinking, since effective change management relies on a collaborative, concerted and coordinated effort across all the actors and all the policies. Most implementation work fails to achieve a balanced approach, and becomes vulnerable to 'weak links'. Assembling the Policy Matrix may require time and effort by all actors, as each prepares proposals and reforms that are in alignment with proposals from others. The object is for everyone to row in the same direction, and to take advantage of the collaborative model by using the influence of partners to remove barriers to implementation.

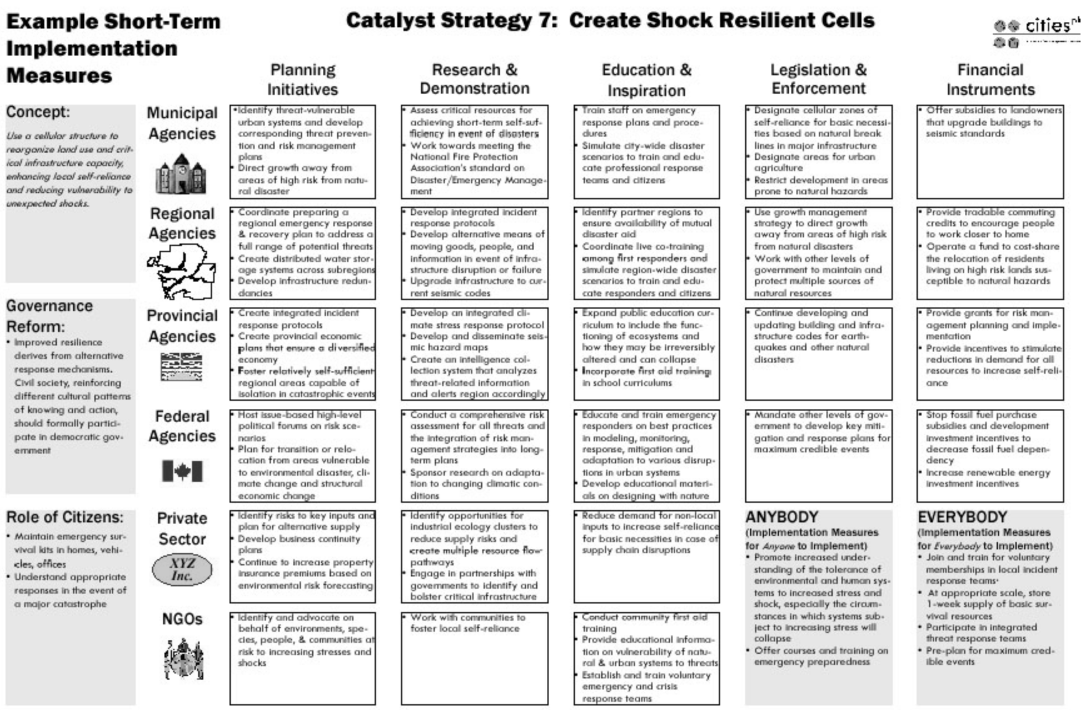

Figure 119 A Policy Matrix indicates how each participant within a Collaborative can use various policy instruments to support a specific catalyst strategy

The fourth step is a set of *Catalyst Projects* selected to accelerate learning and to promote acceptance and understanding of the Catalyst Strategies. A Catalyst Project is site-specific, incorporates one or more of the catalyst strategies, and is supported by policy initiatives. Because of the focus on learning and integration, the catalyst projects are more pilots than demonstrations, purposely structured to increase capacity of the design profession and to improve state of the art. They are an applied version of the learning society, at urban scale. In *CitiesPLUS* the final Sustainable Urban System Design (SUSD) included the inclusion of at least one Catalyst Project in every neighbourhood and utility, intended both as a contribution to SUSD, and as a source of local pride and place-making. Figure 120 evokes a neighbourhood catalyst project, extracted from the Catalyst Gallery, and illustrates how the project serves to anticipate and re-direct performance indicators.

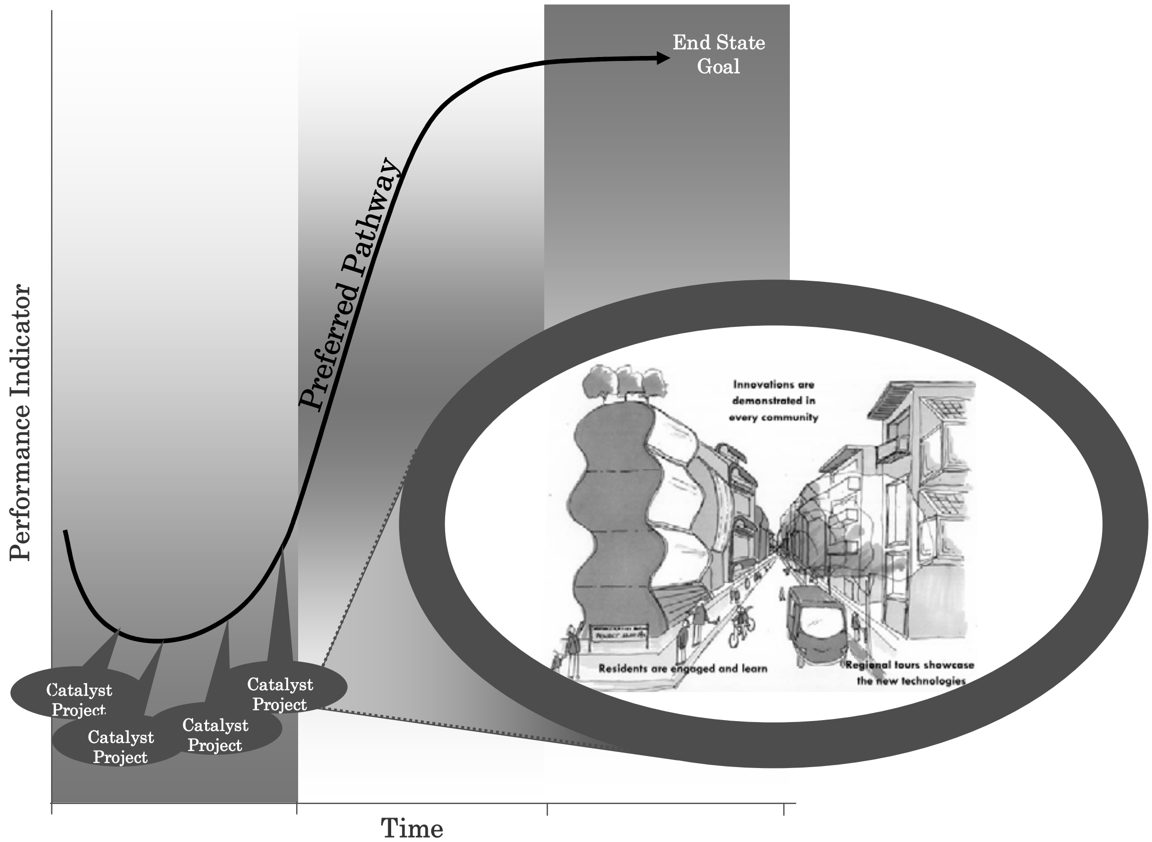

Figure 120 Catalyst Projects are interventions in the short-term designed to satisfy a preferred pathway and end-state goal

The four-step process of Catalyst Intervention offers one structured approach to implementation of new time concepts in urban system design. However the level of complexity is still high, even with the ranking criteria process and visualisation support. The tools are only moderately interactive. Time scales are not addressed in the policy matrix, nor are the synergies and dependencies between the many measures. The process of how to implement specific catalyst projects is still vague. Feasibility studies are needed to explore benefit cost and practicality. An accelerated marketplace may be needed to help broker the investments by private sector partners, and to help them understand how their products and services best fit into the overall regional pathway.

11.5.2 Sustainable Urban Metabolism Modeling

With the evolution of visualization and DSS tools it eventually becomes possible to develop a scalable, open-architecture model that integrates a full suite of design tools so that they can function together at each layer of urban system design. As part of both the *CitiesPLUS* research and the follow-up workshops, the author attempted to create a standardised SUMM.

The intended users were the urban system design teams in each country. The object was to assist teams with scoping, data collection, data processing / conversion / storage, scenario development, mapping and visualizations, and indicator calculations and comparisons. The method is referred to as Sustainable Urban System Modeling (SUMM).

A set of design parameters were defined to make the DSS effective over the longer-term. For example, all tools were required to be: web accessible, scalable to different user needs, clearly associated with specific layers of framework, capable of taking-from and adding-to a common shared database, and tied to a standardised graph or map for visualisation.

A working version of SUMM was applied to the case study. Figure 121 is an overview of the separate tools and how they are integrated. Tools are identified by name and connected to the information process flow. At the centre is Community Viz, a software tool developed for urban modelling by the non-profit Orten Family Foundation in the USA. (see Chapter 3) Community Viz provides a convenient platform for calculating core indicators, and generating scenarios from the Sankey database. It also uses the data to update GIS files in real time, allowing results of scenarios to viewed and compared instantly, or integrated with other GIS layers to form maps and 3D visualisations. The PLUS Sankeys thus became the basis for a scalable environmental accounting system that integrates the core indicators, MFA, GIS and scenario planning.

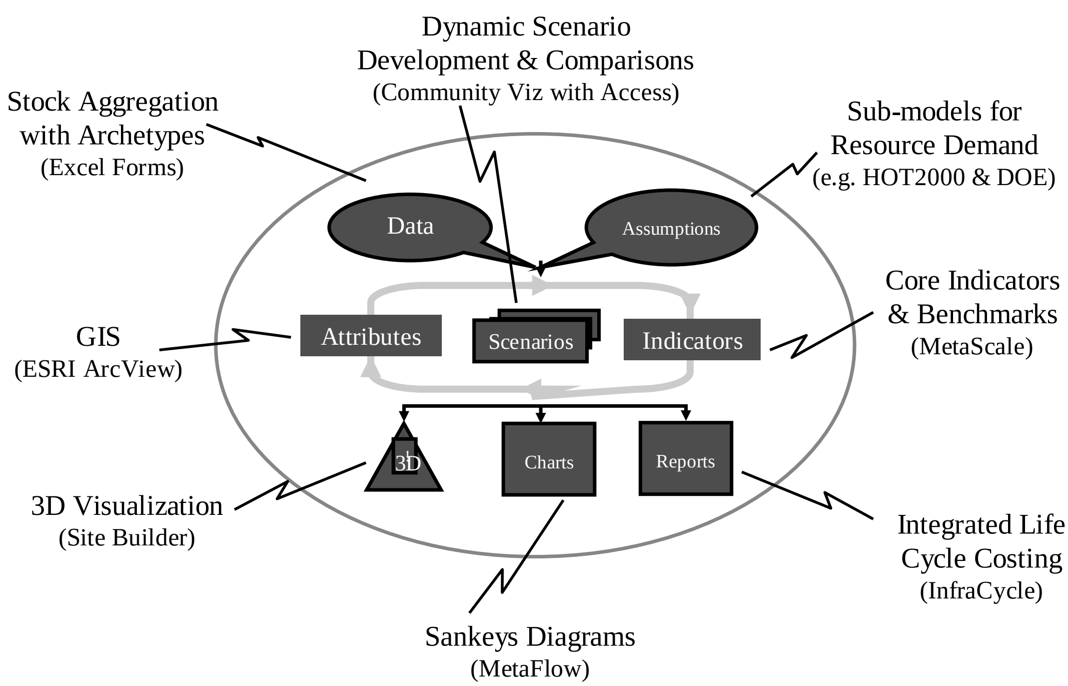

Figure 121 The Sustainable Urban Metabolism Model (SUMM) integrates multiple tools into one application

As should be clear, the software builds upon models and tools already described in this thesis, and thus a detailed discussion is not warranted. The important question is whether such a tool could succeed in simplifying the design process and creating useful new information, especially comparable indictors and improved scenarios for design? For this purpose an effort was made to use Community Viz and SUMM with the Canadian, Dutch, Indian and Chinese teams. This proved possible, but only at a rudimentary level, given the lack of documentation and training resources, and the difficulties with accessing the Digital Elevation Models and building data for each location. What was apparent is that a tool like SUMM has the potential for greatly reducing the time required to create plausible scenarios for urban system design, and for establishing a standard protocol for use of indicators and benchmarks. Another insight is that SUMM provides a platform that can be used by different sub-teams on the same regional design. In particular Community Viz, as a database, provides a very convenient basis for sharing data and integrating results. In the Squamish BC application described in Chapter 7, the common platform was used by three very separate design teams: *Smart Growth* (urban form and transportation); *Pathways* (risk management and natural hazards); and *Bridging to the Future* (30-year pathways for sustainability). In this way the SUMM tool has been shown to work as a platform for all three of the *CitiesPLUS* themes: Livability, Resiliency and Regeneration.

The use of Community Viz as a common platform required frequent meetings between groups, and a common format for describing parcels and flows. Also needed was a shared technical staff that could align the scenarios and integrate data for mutual benefit. For these reasons, a much more intensive exercise is required before the potential of SUMM can be properly evaluated.

A key ingredient in the SUMM design was the PLUS Sankey tool, since this the structure of the data for MFA provides the underlying architecture for the regional modeling. For this purpose the PLUS Sankey Matrix was converted into database tables for calculating indicators directly within the Community Viz platform. Since all parcels are defined in a similar format they can easily hybridise and evolve into any imaginable urban system. Moreover the connections between parcels (e.g. where water comes from and where waste water goes to) can be easily pre-programmed to follow an analytical hierarchy process. Each parcel seeks and finds the closest source with available capacity for meeting demands. Once a build-out scenario is defined, the implications on infrastructure loads and metabolism is automatically output.

Based upon initial trials, the SUMM tool is currently suitable as an evaluation tool for growth management strategies and for sustainable urban system design. It is hard to imagine a locality that would not benefit from such analytical capability. However the most difficult part of the SUMM analysis is still the data collection phase. Much more innovation may be required to expedite this process, before the urban design team can focus primarily on scenario development and evaluation.

11.6 Methods for Long-term Monitoring

Monitoring is the catch word for a larger process of measurement, feedback, accountability, learning, adaptation and alignment. Monitoring is the layer of the SEEIM framework that keeps all other layers up to date with new knowledge and changing circumstances. Given the pace of change for urban systems, and the future forces that threaten to transform urban regions, it is difficult to imagine how a long-term design can continue to remain relevant without effective monitoring. Policies, programs, plans and projects need to respond to changing conditions, to learn from past failures, and to continuously adapt and improve. Thus Monitoring is the policy equivalent of adaptable design. It is resiliency by management.

"Reducing the lead time between challenge and response, establishing rapid and effective monitoring and control, contingency planning, decentralising decision to the points of best information, experimenting, and developing testable alternatives may do more for adaptability than will the original physical characteristics of the thing to be adapted, although the latter is not a negligible quality." [LYNCH 93]

Part of the challenge with institutionalising monitoring activity in Greater Vancouver was engaging the relevant authorities – governments, utilities, housing agencies, parks boards, and so on – over the long-term. Two features of the modern economy are especially problematic. One is the culture of these modern institutions, with their unionized workforce, statutory obligations, and pre-determined budgets. The term 'institutionalising' is often used to refer to the rigid, uncaring application of fixed rules regardless of changing consequences – the very antithesis of monitoring. So how can monitoring be effectively institutionalised?

A second difficulty is the ad hoc nature of the collaborative process, with its ad hoc, informal arrangements and multiple jurisdictions. Who keeps track of performance after the design team has completed their work? After the buildings are built, sold and occupied? After the infrastructure is operational? After the community vision has changed? After the champions are retired and the politicians have been replaced?

In Greater Vancouver a number of groups have been monitoring the environment for sustainability, including The Fraser River Estuary Management Program (FREMP), which monitors the state of the working river and harbour, and the Fraser Basin Council, which monitors sustainability indicators for the whole watershed (see Chapter 7). A number of municipalities are also engaged in monitoring as part of their commitment to State of the Environment Reporting (SOER)[53] – a regular published review of the status of selected urban environmental indicators.

Despite the on-going monitoring of broad environmental indicators by environmental NGOs and through official SOER, monitoring of the core indicators proposed by *CitiesPLUS* is not standard practice, and is complicated by a lack of tools, gaps in data and inconsistent calculation protocols. The regional government lacks a specific mandate and budget for monitoring, although it was nevertheless identified as a priority next step in the SRI for Greater Vancouver. Presumably some combined strategy can be developed, although this was never explored in *CitiesPLUS*.

A monitoring tool was developed as part of *CitiesPLUS*, and the tool became synonymous with the SEEIM framework and the *CitiesPLUS* approach. The tool, referred to as Urban Adaptive Management (UAM), is an attempt to institutionalise monitoring within the context of IDCD.

11.6.1 Urban Adaptive Management

Adaptive management was developed by ecologists in the 1970s to cope with surprise and failure in environmental management. As a design tool, it is simply a framework approach that maintains over the long-term a logical connection between goals, strategies and actions. This is accomplished by means of monitoring, feedback, learning and re-alignment. Adaptive management can work with any principle or goal that the user desires. It this sense it is a form of 'methodological pluralism' – everything fits inside the framework.

Adaptive Management can be characterised as 'ecological' because it incorporates feedback loops that allow the system to respond quickly to change, and to learn in the process. This is analogous to the sensing and processing of information by a living organism. The organism must remain alert, explore opportunities, and avoid being eaten. Urban Adaptive Management applies the concepts of ecological management to Sustainable Urban System Design. If adaptive management can help the urban region sense changes, and respond, the urban systems become more alive.

Figure 122 illustrates the sequence of activities that together create UAM. Alignment between the layers of the framework is first accomplished using a procedure for indexing and referencing. Measurement of performance is accomplished using the core indicators described in Solution Space

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[53] SOER is a process that has been pioneered by the Canadian government, and that has now been adopted by many provinces and municipalities. For more information, see:

Planning. Feedback is accomplished by designing refresh rates for each level of the framework. Accountability is accomplished by integrating the performance measurements into public documents, review processes, and job performance reviews. Learning is accomplished by comparing the monitored results with other locations, and against targets and other expectations. Adaptation is accomplished by revising layers of the SEEIM framework to reflect the learning, and by re-aligning subsequent levels within the framework to maintain logical consistency.

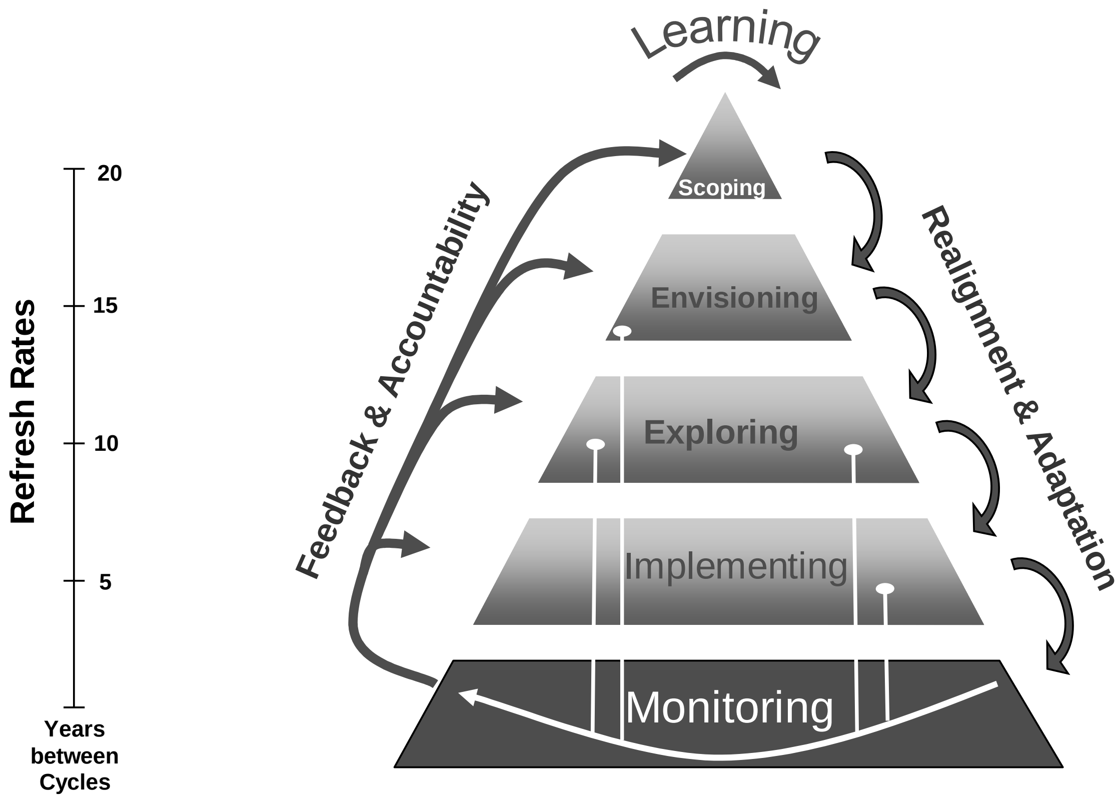

Figure 122 Urban Adaptive Management is a time cycle approach to sustainability, based upon alignment, monitoring, feedback and learning

A number of innovations were explored within *CitiesPLUS* in an effort to operationalise these UAM activities.

Alignment

Alignment refers to the process of establishing and maintaining logical connections between adjacent levels within the SEEIM framework. Through alignment a vision can be translated into appropriate actions and results. Alignment serves both to reduce complexity within the framework, and to adapt the contents of the framework as time goes by

In *CitiesPLUS* a computerized reference database was used to align the contents of the design beginning with the many end-state goals. A similar data-basing tool was also developed by the regional government as part of the SRI work. An indexed data-base makes it possible to sort and filter all elements of the design based upon user-selected criteria. For example: what goals are related to any particular target? Or what design projects are related to a particular goal? The data-base was used frequently by the core team to keep track of the design exercise, and to identify synergies and catalyst strategies.

Secondly it creates an automatic rationale for every design solution, providing clear and direct explanations that educate the designer or user about the context for design decisions. Such rationales are especially valuable when decision-makers encounter resistance from impacted groups. For example, if the design appears costly, it may help to follow the framework backwards, from the required actions to visions and values, and thereby reinforce the potential benefits. The framework becomes a tool for clarifying intentions, and for focusing discussion on those areas where conflicts may require resolution.

Alignment is a process that creates logical connections throughout the framework. For example, the *CitiesPLUS* vision statement included the sentence: "We will preserve and nurture the living systems of this region and all other places through stewardship of the fundamental resources of healthy food, soil, air and water." A sub-vision for water systems elaborates on this statements, envisioning that "The water system is sustainably managed by emulating the natural hydrological cycle and respecting non-human uses of water." This subsidiary statement was unbundled into many goals, one of which was: "Emissions and waste into streams and bodies of water are controlled in ways that protect the continued ecological health of the water system." The goal was then expressed as a monitoring target: "Percentage of Urban Land Area with Effective Imperviousness Equivalent to Pre-Development Levels (Target = 100 %)". This was also expressed as a design target: "Achieve an effective permeability rating of 10% for residential land uses by 2021 ". This target was addressed by means of preferred strategies, one of which included: "Preserve natural drainage patterns on all sites." The strategy was achieved be means of design innovations in the Catalyst Gallery, one of which was a practice titled: "Direct roof drainage into cisterns and infiltration trenches ". Another was titled: "Select surface materials that maximise run-off retention and infiltration". These practices were then used to illustrate the Catalyst Strategy of "Webs of Green, Ribbons of Blue" and were supported by recommendations for changing development guidelines and fiscal policy to support the new technology.

Alignment of levels must be transparent to all users in order to be beneficial. Goals, objectives, policies, plans, and projects represent a hierarchy of community intent as well as the progressive translation of general ideas onto operational targets, strategies, projects and improvements. [HODGE 1998] One way to achieve transparency is to restate the connecting rationales every time a specific design element is displayed. The *CitiesPLUS* report on targets provide an example, since each target includes a list of the related goals -one layer up, and the proposed strategies - one layer down. [www.*CitiesPLUS*.ca Targets]

Measurement and Feedback

Monitoring provides quantitative feedback that is an essential part of the learning process. In the words of Philip Tipping at the World Conservation Union "Trials should be informed by quantitative models, or other clear articulation of how and why the managed system is expected to respond to proposed management actions. If plausible, the options for management should be presented as strongly contrasting alternatives that can be compared by doing, so that the "errors" point reliably to paths for improved performance. Managing resources should be treated as large scale, long term experimentation, subject to the discipline demanded by science and the experimental method." [TIPPING 02]

The use of performance indicators as measurement tools often leads to confusion during the design exercise. At the Envisioning layer, post construction indicators can be proposed to measure how well a particular project is actually performing over its lifetime. At the Implementing layer, pre-construction indicators can be used to assess blueprints and inform and guide the design team. In the context of UAM, the feedback systems are based upon the post-construction indicators, sometime referred to as 'monitoring indicators'.

Long-term performance monitoring may require that 'refresh rates' be established for each layer of the framework. The intention would be to institutionalize the process of measurement and feedback so that it is manageable, affordable and inevitable. Refresh rates are scheduled. However they also put in place a process that can be initiated on demand, should the region encounter unexpected shocks or threats that require revisions to existing system design. Thus the refresh rates help to transform the framework into a cyclical process more in line with an ecological approach to resiliency.

Refresh rates for SEEIM layers presumably can be matched to reflect the rate of change occurring within society, and fine-tuned to correspond with the varying time rings for the urban systems. In Greater Vancouver, for example, a long-term vision called *Creating our Region* [LRSP] had served the region well for the 12 years preceding *CitiesPLUS*. In the view of the core team the vision had become out-of-date, especially due to the absence of any reference to ecological sustainability, resiliency and global connections. Based upon this one case study, goals and visions for a growing urban region may need to be refreshed on average every 12 to 15 years, strategies every 10 years, and specific programs and designs every 5 years. Systems experiencing rapid changes in technology and values, like transportation, would of course benefit from more frequent adaptation and alignment.

Evaluating appropriate refresh rates was not possible within the time period of this thesis research. It is possible to imagine adaptive management systems that are too slow to change, and others that are too fast. Lynch warns against the potential for over-corrective swings in management processes. Large visionary plans sometimes never get beyond the first stage before conditions change, the plan drifts, and planners and designers start all over again. “We need to learn not only to adapt efficiently but to infuse adaptation with purpose and value. …. Flexible form and action must be coupled with a clear concept of desired performance, and actual performance must be monitored to see how it varies with respect to that standard. The standard is itself subject to reappraisal and change.” [LYNCH 93]

Management and Resiliency

The resiliency of urban regions emerged as a central theme in the *CitiesPLUS* design for all the reasons discussed in Chapter 7. In the final Sustainable Urban Systems Design (SUSD), resiliency was joined with ecological sustainability and livability to create a new ‘triple helix DNA’ for regional growth. The helix is a metaphor both for the evolutionary process, and for using information as a foundation to learning and physical growth. The three strands reflect the new priorities for region’s long-term vision statement, and are intended to be mutually supporting. Thus the emphasis on resiliency has redefined the core of the SEEIM design framework. In Figure 123 the triple helix is shown as a pillar within the framework, ensuring that resiliency is addressed at every layer, from visions to actions.

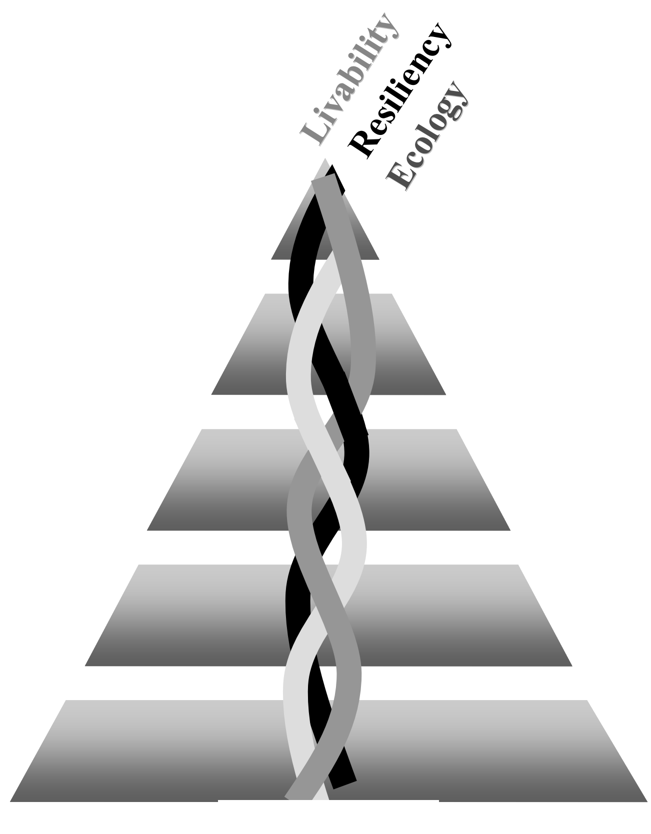

Figure 123 Resiliency becomes a core theme, interacting with the other themes to direct the design at each layer in the framework

Although it is logical to assume the theme of resiliency was a direct outcome of time extensions alone, it is interesting to note that resiliency was not even mentioned in the other 100-year design submissions. No easy explanation can be offered for this contrast. It is possible that resiliency does not fit well into the sustainability paradigm, which has within it an assumption of a steady-state system with a balanced approach to a set of frozen values: economic, social, cultural and environmental. In other words by stipulating sustainable system design in the terms of reference the scope becomes restricted to solving known problems, rather than risk management and responsiveness. More recent efforts at long-term systems design have placed a greater emphasis on resiliency.[54]

Combining resiliency with sustainability creates a new paradigm for design that is illustrated in Figure 124. The TNS funnel is further modified to reflect 1. the pace of change and a design orientation; and 2. the likelihood

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[54] Vancouver Resiliency planning modeled on the *CitiesPLUS* experience is now underway as part of a special long-term initiative in the Regional Municipality of Ottawa Carleton, Canada, (http://www.ottawa.ca/city_services/planningzoning/news_events/sustainability_en.shtml) and the Region of Auckland, New Zealand.

of unexpected shocks. The design strategies for long-term success are the flip side of stressors: over-consumption becomes dematerialization; loss of ecosystem services becomes regeneration. Most significantly, natural hazards along the top of the funnel can coincide with socio-economic disasters along the bottom. The example shown suggests a natural gas shortage occurring at the same time as an extreme heat wave: a scenario which can lead to hardship and even deaths in many cities where air conditioning is powered by thermal generators. The affect of frequent and diverse disaster scenarios is to radically reduce survival space – creating pinch points for risk management.

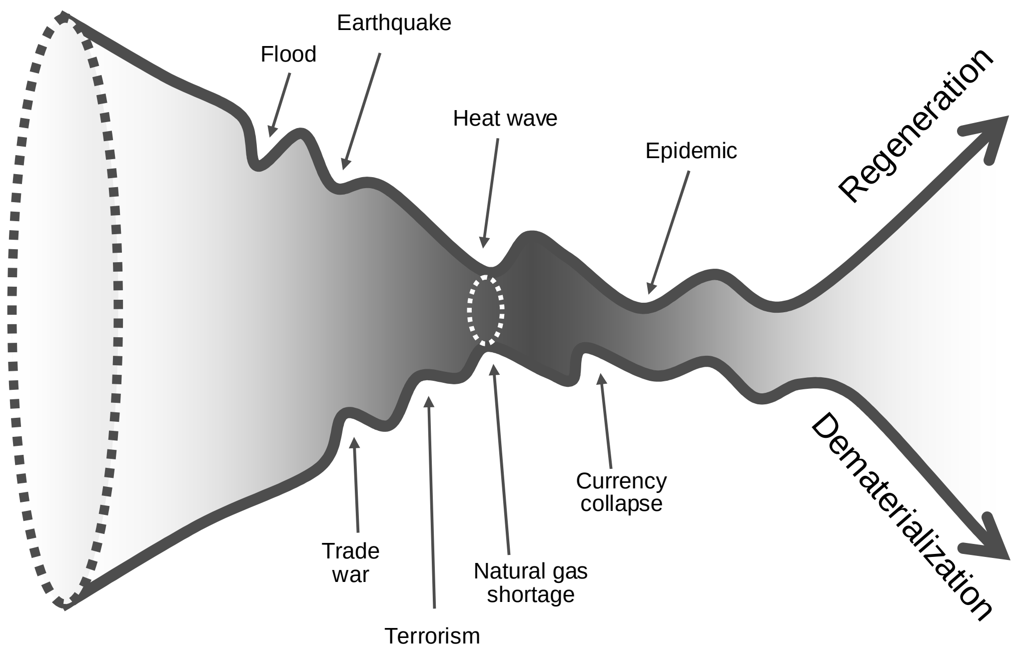


Figure 124 The Sustainability Funnel can be revised to reflect the pace of change and the pinch points from environmental and socio-economic disasters

A Syntropic Design Framework

It is now possible to imagine a combination of normative and technological design frameworks that is capable of adapting to changing conditions, and surviving the test of time. Figure 125 is a composite schematic and graphic. The framework is shown to be three-dimensional. The spiralling design process circles around each layer in the framework, and in so doing touches upon the full efflorescence of the selected urban systems. The circling motion represents the Integrated Design and Collaborative Decision-making process, and the creation of one 'Kaleidoscopic' system.

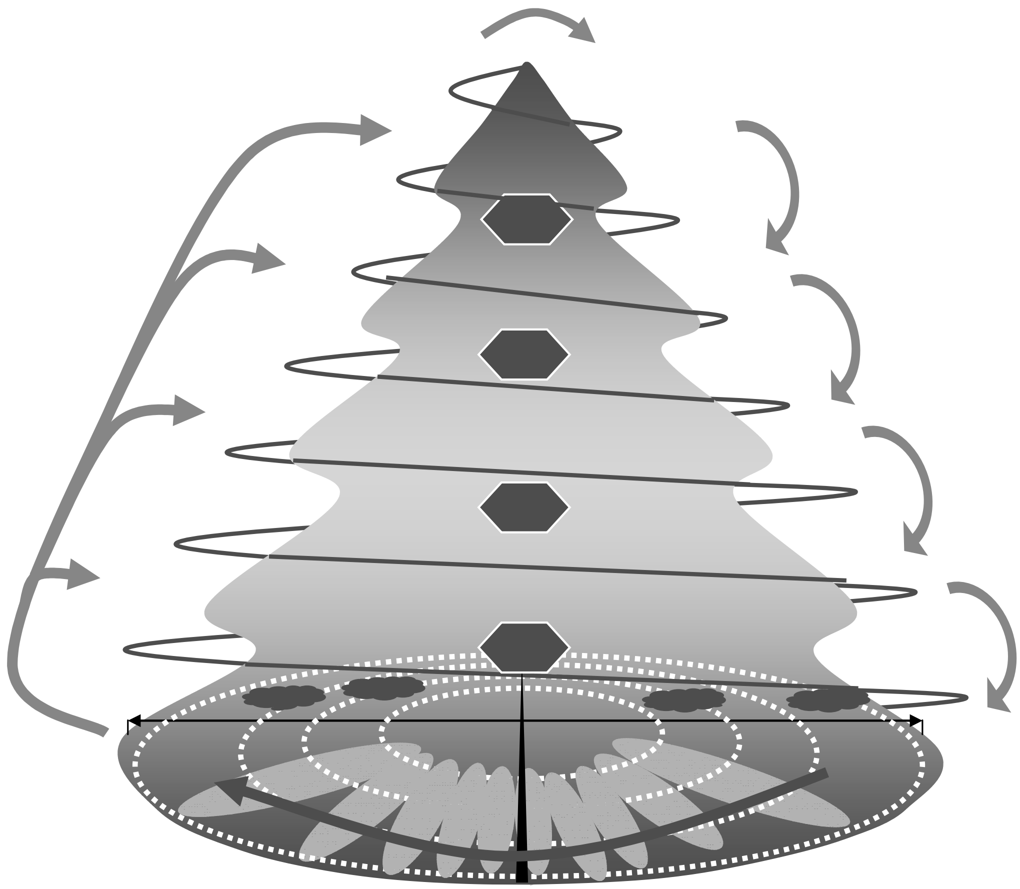


Figure 125 A Syntropic Design Framework integrates many of the new timing concepts for management and design

At each layer the key driving forces are also considered, in term of threats and opportunities. At each layer in the framework a combination of timing tools make the framework practical: Solution Corridors help to reduce complexity manage the pace of change; Influence Intervention Diagrams and Urban Shock Testing help urban designers respond to the potential threats and shocks. At each layer bi-directional (horizontal) time scales provide a long-view for the narratives, scenarios and other models. At the base of the framework the PLUS divides the core team and advisors into the key sectors of government, academia, private and civil – united in a collaborative model of decision-making and management.

The framework itself is animated over time – it is four dimensional. Chronologically the process of design moves vertically, from top to bottom. At the foundation layer the process begins to cycle in time, refreshing the design choices at appropriate intervals. Periodic feedback from monitoring leads to learning, adaptation and re-alignment of the layers – an Urban Adaptive Management system. In this way, with luck and perseverance, it may be possible for urban regions in the 21st century to practice long-term urban system design.

PART 5: FINAL THOUGHTS

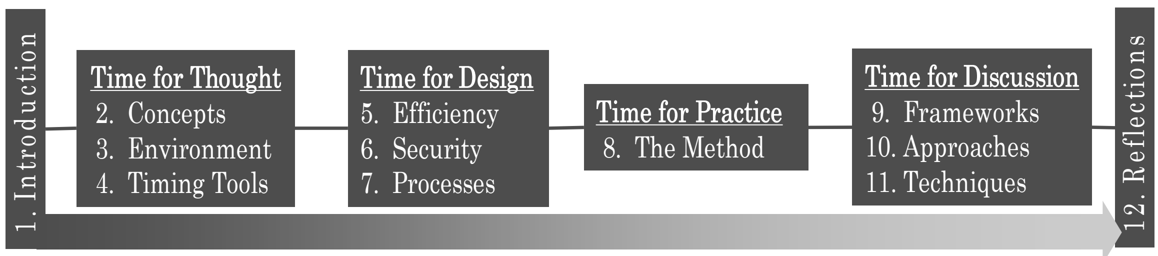
I confess to thee, O' Lord, that I am as yet ignorant as to what time is. And again I confess to thee, O Lord, that I know that I am speaking all these things in time, and that I have already spoken of time a long time, and that 'very long' is not long except when measured by the duration of time. How, then, do I know this, when I do not know what time is? Or, is it possible that I do not know how I can express what I do know? Alas for me! I do not even know the extent of my own ignorance.

St Augustine, "Confessions" 398 AD

12 Reflections

The research has covered a broad scope of concepts and experiments in a search for clarity on how new time concepts might impact sustainable urban system design. Insights have been discussed throughout previous chapters, with respect to questions raised in Chapter 1.

In this final chapter a brief overview will be provided of the primary findings. However what is perhaps most interesting to reflect upon at this stage are the many new questions that have emerged during the research, and that may represent fruitful directions for new enquiry. This chapter will describe a few such questions.



12.1 An Overview of Key Findings

A review of the historical and philosophical debate on time concepts has indicated that human time is primarily a cultural artefact; timing tools are a type of language that is fundamental to humanity, and yet has changed significantly over time. A review of time concepts in design has indicated that constructed environments have always served to direct and regulate the course of change, and to reinforce the cultural time concepts. In a post-modern world, the timing functions of the constructed environment may be part of the challenge for sustainable development. At present the environment appears to contribute to shrinking of time horizons by ignoring or confusing images of past and future.

A review of timing tools available to communities and design professionals has revealed a wide assortment of tools, many of which have potential application to urban design. Several powerful analytical methods – LCA and MFA – may also assist in developing long-term and resilient regional system design. Historically the success of such methods and tools is very limited, and almost none are currently in use by practicing urban designers and community decision-makers. Many opportunities exist for adapting such tools to long-term urban system design.

New time concepts such as time extensions, time rings and time cycles introduce perspectives that are simple, yet profound in their potential impact on design methods and frameworks. By capturing positive synergies and allowing a systems approach, these new concepts help to operationalise a more ecological and evolutionary approach to design, an approach which appears to support design features that are substantially more efficient and more adaptable than the norm. By exposing the increasing diversity of threats, the frequency and inevitability of shocks and disasters, and the accelerating pace of change for many key driving forces, the new time concepts help to expand the meaning of sustainability to include long-term resiliency and security through design. The new time concepts also emphasise the importance of adopting a regional perspective that combines the local web of urban centres and their surrounding infrastructure and natural systems - and of engaging many actors in a collaborative and rational process of design.

A many-faceted case study of time and design for Greater Vancouver has revealed some of the benefits of applying new time concepts, as well as some of the challenges. On the basis of this single detailed example, time concepts appear to have considerable influence on the process of design, the composition of design teams, and the scope of the design programme. Comparisons with international case studies have confirmed some of the positive influences– particularly the synergy between new time concepts and ecological models.

The Greater Vancouver case study included many experiments with new design methods and tools. A new design framework emerged that was found to be suitable for the creating and managing a collaborative design team, and for generating integrated long-term design solutions. New tools were found necessary at every stage in the design framework, as a way both to improve communications and to cope with complexity – factors that have always frustrated design teams but that appear to be especially problematic when introducing new time concepts. The framework tools described in the thesis appear to be transferable, and thus may warrant further development as a means to assist urban regions elsewhere.

12.2 Outstanding Questions

The following questions have emerged from the research, and address some of the basic assumptions that underlie the research.

Do we need a 'pattern language' for temporality?

If systems thinking is the solution to coping with complexity, and if visualisation is vital to communicating new paradigms, and if time is primarily a language for orientation and synchronization, is it desirable to develop a more systemic, visual and universal set of terms and images for expressing how elements of a region perform over the long-term? How can such temporal patterns evolve and become part of a shared vocabulary? Where is the place to start: the ecological footprint, the temporal Sankey, the LCA combined with a forecasting GIS, the design framework that has refresh rates and alignment for adaptive management, the solution space for backcasting, the catalyst galleries?

Is information the key to making long-term thinking a norm?

If more information on the long-term past and future, and a better understanding of historical trends and patterns of change, serves to make individuals experience the long-term as closer to the present – i.e. long *becomes* short-term - is it possible to achieve sustainable design outcomes simply by properly orienting designers and decision-makers to the context of what has occurred, and is likely to occur, to the local systems over the long-term? Have communities and design professionals underestimated the value and impact of contextual orientation in time?

Is sustainable design sustainable?

If urban system design at the regional scale is dependant upon an informal process of collaboration and consensus decision-making – something that by definition lies outside the mandate of existing institutions and traditional mechanisms for financial accountability - how is it possible for regions to obtain the long-term financial and human resources that will be needed to sustain a sustainable design process?

Is the real design challenge to learn about learning?

If the security of urban regions increasingly depends upon the capacity of a 'learning society' to develop public/private information networks ('webs') and to formulate and implement intelligent design responses to continuously changing threats, is the real challenge of design to learn about how both the systems and the designers can continuously learn? Why does it seem that sustainable design projects imagine performance indicators for everything but learning?

Is transdisciplinarity a researcher's fairytale?

If creative and successful designers share a mind set that is predominately visual and intuitive, and a work process that is fast and iterative, is it conceivable that designers will ever be fully supportive of a regional-scale long-term approach that is by nature tedious and complex, and requires an extensive public and analytical process supported by DSS tools? Even with supportive mechanisms for conflict resolution, team building, and translation, is it practical and effective to actually combine spatial design teams with equivalent strength of expertise in physical flows and externalities?

Are the win-win arguments counterproductive?

If one of the prime reasons for high time preferences is the increasing pre-eminence of individual preferences both in the marketplace and the political arena, are strategies that emphasise profitability and other short-term benefits of 'green' design ultimately part of the problem? What is the balance between incentive based-policy reform, and a change in value sets and identity that promote disinterested altruism in urban design choices?

Is heritage preservation missing the future?

If the timing functions of urban environments require a 'temporal collage' that brings together past, present and future in a coherent narrative, and if time scales for design are bi-directional (stretching to past and future), does the current focus by communities on heritage preservation need to be redefined to include a future perfect, a future of the past, a preservation of the future? Can the same sense of special caring, tolerance, romance and respect that we give to heritage structures also be given to utopian visions and adaptable designs? Can communities invest in the built environment potential in the same way we invest in our children's potential?

Does the lack of constraints constrain design solutions?

If fossil fuels have allowed designers and communities to ignore history and the constraints of local climate, natural hazards, energy-scapes and water cycles, and long-term projections, does a sustainable design philosophy need to redefine the value of constraints per se? Is post-modern architecture simply a rediscovery of the the beauty and excitement and necessity of designing to constraints? Are time concepts simply an ingredient of a renewed aesthetic based upon ethics and limited resources?

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