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A Maturity Model for Transformability in Hospital Systems

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Abstract

Hospitals face increasing challenges due to dynamic external and internal factors such as demographic shifts, technological advances, and financial constraints. Addressing these challenges requires adaptable and future-proof infrastructure. Based on principles successfully applied in factory planning, this study introduces a Transformability Maturity Model (TMM) tailored to hospital systems. The TMM evaluates transformability of hospitals by systematically assessing hospital objects (categorized under technology and space design fields) through defined Transformability Potential Features (TPFs).

This hierarchical model uses quantitative and qualitative measures to identify the current maturity level of hospital and provide actionable insights for improvement. The assessment results are visualized in a spider diagram, highlighting strengths and areas needing attention. The model has been validated through an in-depth assessment of a sample hospital, led by an experienced hospital quality manager, confirming its practicality and applicability in real-world healthcare environments.

By adopting this model, hospitals can systematically plan and execute transformation strategies to ensure adaptability to evolving needs. This study provides a robust framework for designing, future-ready healthcare systems capable of adapting to change efficiently and with minimal disruption to meet the pressing demands of modern healthcare.

Keywords

Hospital Planning; Maturity Model; Transformability Assessment; Transformability Maturity; Factory Planning

1. Introduction

With multiple external and internal change drivers such as demographic changes, digital transformation, and financial constraints, hospitals face an increasing demand for adaptability [1]. These changes require a level of flexibility that many hospital infrastructures, with their static and fixed designs, cannot provide [2]. This challenge highlights the need for a structured and systemic approach to hospital planning that ensures transformability [3].

Transformability in the hospital is the ability to efficiently and effectively modify, adapt, and reconfigure structural, spatial, technological, and organizational elements with minimal disruption, ensuring that hospitals can keep up with both internal and external changes [4, 5, 6]. This approach has already been utilized in factory planning to improve the efficiency and responsiveness of production systems [7, 8, 6].

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Based on the similarities between factory and hospital systems, studies have been conducted to transfer these principles.

One of the main goals of MedFAP was to provide a structured and comprehensive method for implementing transformability in hospitals [9]. To achieve this goal, hospital objects were first identified and categorized into three groups: technology, space, and organization [10]. Subsequently, Transformability Potential Features (TPFs) were defined for each group of objects through literature reviews and expert interviews [11]. Through the transfer to a maturity model, these TPFs can be used as concrete measures to assess the level of transformability of a hospital.

Maturity models are widely used frameworks for evaluating progress and capability, providing structured roadmaps for evaluating performance, identifying areas for improvement and promoting continuous growth [12].

To assess the transformability level of a hospital, this paper presents a maturity model for evaluating and improving the transformability of hospital by focusing on design and technology. By defining this model, the paper aims to provide a structured framework to support strategic planning and continuous improvement of hospital systems.

The proposed maturity model builds on previous research that has identified key TPFs across various hospital objects [3]. The methodology involves identifying the best practical description of TPFs to qualitatively differentiate different stages and validating of these features through expert consultation. This approach ensures that the model is both practical and adaptable.

2. Background

2.1 Transformability, Hospital Objects and Transformability Potential Features

WECKEN ET AL. [11] extensively reviewed existing terms for transformability like: Adaptability, Changeability, Convertibility, Flexibility, Expandability, Transformability and Future proofing. Future proofing is used in hospital planning which refers to optional design possibilities in preparation for future changes [13]. Transformability refers to the ability of a system to implement structural changes with minimal effort to adapt to evolving requirements [14] and was originally developed in the context of factory planning [6]. Hospitals face different challenges that force them to respond effectively and purposefully to changing needs while maintaining their operations during the transformation process to ensure a sustainable and resilient healthcare infrastructure.

To achieve transformability in hospitals, as in manufacturing systems, the first essential step was to identify hospital objects as the fundamental elements of a hospital system that can undergo or influence change. Based on defined system levels and design fields, hospital objects were systematically identified and categorized [10]. These objects form the basis for operationalizing transformability by enabling targeted evaluations and interventions.

Transformability Potential Features (TPFs) are specific attributes or characteristics of hospital objects that collectively enable the hospital system to effectively adapt to environmental change drivers [6]. With the help of a maturity model, TPFs not only facilitate the evaluation of a hospital system's current and desired state of transformability but also serve as a basis for defining concrete measures to improve transformability. By leveraging TPFs, hospitals can systematically improve their transformability and create future-proof healthcare systems capable of addressing emerging challenges.

2.2 Maturity models

2.2.1 Maturity definition

The Oxford English Dictionary describes **Maturity** as: “the state of being mature; fullness or perfection of development or growth”. Maturity is usually measured in terms of capabilities. A capability can be described as the “power or ability in general, whether physical or mental” to fulfil specified tasks and goals. Therefore, from a linguistic perspective the purpose of models dealing with maturity is to outline the conditions under which certain examined objects reach the best or perfect state for their intended purpose [15].

2.2.2 Maturity model

Maturity models describe the development of entities such as processes or capabilities over time and assess their progress toward optimal performance [16]. According to WENDLER [15], maturity models have two primary perspectives: 1) a life cycle perspective, where the entity moves through stages of growth to a final state of maturity, similar to a natural life cycle and 2) a potential performance perspective, which focuses on the potential improvements an entity can achieve by moving through different stages of development. In this perspective, the potentials resulting from a higher maturity level could be shown and the user can decide if it is desirable or economically feasible to proceed to the next stage [15].

In general, maturity models are utilized for three main purposes:

- Descriptive tool: enabling the assessment of the "current state" by identifying strengths and weaknesses.
- Prescriptive tool: facilitating the development of a roadmap for improvement.
- Comparative tool: enabling benchmarking against industry standards and other organizations [17]

2.2.3 Key elements of a maturity model

Maturity Stages/ Levels: The core of a maturity model is a sequence of maturity levels, which describe the progression from initial to advanced stages of development. These stages are hierarchical and sequential, meaning each stage builds upon the previous one [18].

Criteria for Measurement: The model must include clear criteria to assess the maturity of the entity, such as capabilities, processes, or performance outcomes. Some models focus on a single dimension (one-dimensional models), but most are multi-dimensional, assessing different aspects of an organization or process [18].

Improvement Process: Maturity models should provide a structured plan or set of actions to progress to the next level. This roadmap outlines what needs to be changed or improved, the resources required, and the timelines for achieving these goals. The roadmap essentially transforms the maturity model from a diagnostic tool into a strategic guide for growth and development. The maturity model approach is commonly used to determine the current maturity level and generate a roadmap that should be followed to move to the next level [18].

3. Transformability Maturity Model

The Transformability Maturity Model (TMM) which is introduced in this article (Figure 1), is a structured framework designed to evaluate and improve the transformability of hospital systems by systematically assessing their components, previously referred to and further discussed by WECKEN ET AL. [10] as hospital objects. These objects, as fundamental elements of a hospital system, influence or undergo changes

in response to evolving environmental, operational, and structural requirements. The model operationalizes the concept of transformability by leveraging Transformability Potential Features (TPFs) [3] —specific attributes or characteristics of hospital objects that collectively enable adaptation.

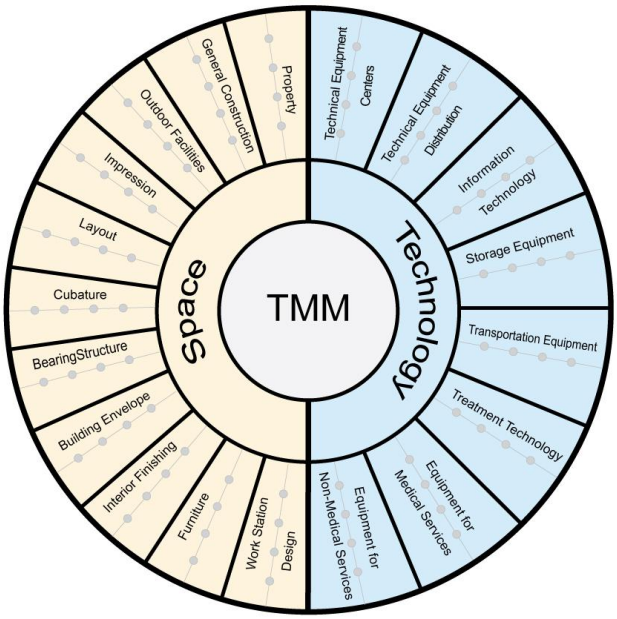

Figure 1 - Transformability Maturity Model

The maturity model is inherently hierarchical, integrating both qualitative and quantitative assessments. At its core, each hospital object is associated with a set of TPFs [3], which represent key enablers of transformability. These TPFs are systematically scored based on a predefined scale ranging from 1 to 5, with the following level descriptions:

1: The status mentioned in the TPF is addressed in an informal or ad hoc manner and is not always reliable.
2: The status mentioned in the TPF exists in some cases is in place with limited functionality and in a reactive manner.
3: The status mentioned in the TPF is widely functional but without a systematic and holistic approach, with no monitoring process in place.
4: The status mentioned in the TPF is operational and functional in a proactive manner.
5: The status mentioned in the TPF is established via a systematic approach and is embedded as a routine activity or comprehensively integrated across the entire organization.

In the appendix a description of each TPF status is provided. The average score of the TPFs assigned to a hospital object determines the maturity level of that specific object. The overall Transformability Maturity Score of the hospital system is determined by aggregating the maturity levels of all hospital objects, which is then visualized in a spider diagram for a clear and comprehensive representation.

It is evident that the optimal state occurs when all hospital objects reach level 5, which maximizes the radius of the spider diagram. The ultimate goal for a hospital that claims to operate at the highest level of transformability is to achieve this state.

The evaluation process can be conducted either as a self-assessment or by engaging a third-party evaluator [19]. In either case, it is essential to have a **group** of assessors who are not only fully familiar with the concept of transformability to ensure an accurate understanding of scoring each indicator but also to minimize the effect of individual biases on the final result. The assessment includes the following key steps:

- Assessment of the TPFs for each hospital object:
  During the assessment, evaluators or hospital managers score the TPFs based on how closely they align with the ideal transformability. A score of 5 is awarded when the attribute fully satisfies the defined criteria, while lower scores reflect partial or minimal alignment.
- Calculating hospital object maturity level:
  The individual TPF scores are averaged to derive a maturity score for each hospital object. This step ensures that the model captures the nuanced differences between objects' contributions to the overall transformability of the system.
- Spider diagram:
  The maturity scores of all hospital objects will be shown in spider diagram to visualize the overall status of hospital's transformability and generate a holistic Transformability Maturity view. This score reflects the system's readiness to adapt to future challenges and changing needs, enabling hospitals to identify areas for improvement and prioritize interventions.

For a sample hospital an assessment was conducted to evaluate its transformability maturity across various hospital objects and to validate the model. This process was guided by a highly experienced hospital expert, who brought over 20 years of experience as a quality manager in the healthcare sector. Her extensive knowledge and practical experience ensured that the evaluation was both accurate and aligned with real-world hospital operations, adding credibility and depth to the validation process. For instance, the results of the hospital's "Impression" object assessment are shown in Table 1. This spider diagram (Figure 2) illustrates the aggregated results of all assessed hospital objects, providing a comprehensive view of the hospital's overall maturity level. The visualization effectively highlights the strengths and areas for improvement, enabling a strategic approach to enhance the hospital's transformability.

Table 1 – The scores of the maturity level of a sample hospital in Space Field, Impression Object

Impression		**Level: 3**
Clarity of lines and shapes	Clear lines and shapes create a simple and organized outdoor layout.	1 2 **3** 4 5
Simplicity	The outdoor area is functional and avoids unnecessary elements like decorations.	1 2 **3** 4 5
Proportionality	Elements are proportionally designed regarding dimensions (e.g., path lengths, rest areas).	1 **2** 3 4 5
Colouring	The outdoor area's color scheme is simple, avoiding trendy or striking colors.	1 2 3 **4** 5

This maturity model enables hospitals to systematically evaluate their transformability and plan for improvement. Whether applied through self-assessment or third-party evaluations, the model ensures a consistent and structured approach to measuring transformability. The quantification of TPFs and their integration into a hospital's operational framework make the model a practical tool for designing transformable healthcare systems.

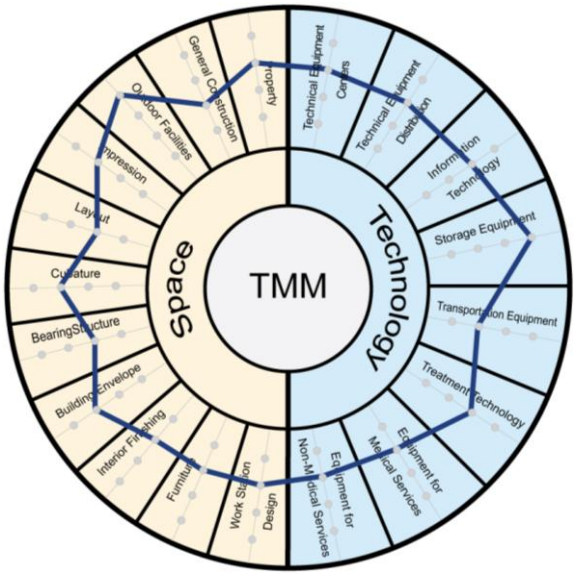

Figure 2 – The overall Maturity Status of the sample hospital

4. Conclusion

In this paper, a comprehensive maturity model for transformability in hospital systems was developed and validated. The proposed model provides a systematic framework to assess the transformability of hospital infrastructures by analyzing Transformability Potential Features (TPFs) across identified hospital objects, categorized under space and technology design fields. Through a hierarchical structure and scoring system, the model enables hospitals to identify their current transformability status and strategically prioritize improvement efforts to meet evolving healthcare demands.

The validation process involved a meticulous assessment conducted in collaboration with a highly experienced hospital quality manager, ensuring the model's relevance and applicability in practical settings. To enhance the robustness of the evaluation process and reduce individual biases, it is recommended that multiple assessors be involved, provided they possess sufficient expertise in transformability concepts. By applying the model to a sample hospital, the study showcased its ability to evaluate the transformability of hospital objects systematically. The process highlighted not only the current maturity levels but also the specific areas requiring improvement, thereby offering a clear pathway for enhancing hospital transformability.

While the current model establishes a structured qualitative framework, further development is required to enhance its quantitative rigor. Future research should focus on refining the scoring methodology by integrating quantitative metrics to strengthen its applicability in complex hospital environments. This maturity model introduces a groundbreaking approach to hospital planning, mirroring the principles successfully applied in factory systems to achieve transformability. By systematically assessing and improving hospital objects, the model provides a structured methodology for designing healthcare systems capable of adapting to dynamic changes, whether operational, technological, or demographic. This innovative framework lays the foundation for transforming hospitals into future-ready institutions, equipped to handle evolving challenges with minimal disruption to their core functions.

Furthermore, as the first maturity model developed in the domain of hospital transformability, this work pioneers a new perspective in healthcare system planning. Expanding on this foundation, future studies should apply the model across various hospital types to assess its scalability and applicability in different healthcare settings. Additionally, further refinements may focus on the development of quantitative tools to enhance measurement precision, ensuring a more data-driven approach to transformability assessment.

Acknowledgements

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Appendix

Transformability Potential Features of Hospital Objects in the Design Field Technology is shown in Table A-1 and Transformability Potential Features of Hospital Objects in the Design Field Space in Table A-2.

Table A-1

Technical Equipment - Centers		Level
Special requirements	The system has no special requirements, ensuring full compatibility with operational needs.	1 2 3 4 5
Insensitivity	The system is fully resistant to vibrations, temperature, noise, and contamination.	1 2 3 4 5
Emission	The system does not emit vibrations, temperature, noise, or contamination.	1 2 3 4 5
Width	The system's width ensures adaptability for transport and modularity.	1 2 3 4 5
Length	The system's length ensures adaptability for transport and modularity.	1 2 3 4 5
Height	The system's height ensures adaptability for transport and modularity.	1 2 3 4 5
Weight	The system's weight ensures adaptability for transport and modularity.	1 2 3 4 5
Degree of connectivity	The system is securely connected to the floor, ceiling, or structure for stability.	1 2 3 4 5
Transportability	Basic transportability and necessary transport tools are in place.	1 2 3 4 5
Load-bearing capacity	System is self-supporting or includes a supporting frame.	1 2 3 4 5
Power supply	Outsourcing preferred for faster expansion or reduction.	1 2 3 4 5
System architecture	Functions implemented in independent and standardized modules.	1 2 3 4 5
Usability	Easy operation after a brief introduction, facilitating operator changes.	1 2 3 4 5
Documentation	Clear, multilingual manual, always accessible, with visible nameplate for key info.	1 2 3 4 5
Electrical supply	The central unit supports flexible and adaptable power connections.	1 2 3 4 5
Type of connections	Standardized and user-friendly utility and data connections (e.g., quick couplings or plugs).	1 2 3 4 5
Decentralisation	The system can be expanded or reduced using standardized, decentralized modules	1 2 3 4 5

Commissioning	Quick commissioning during changes with diagnostic capabilities (self-tests) and pre-checks.	1 2 3 4 5
Capacity reserves	Capacity reserves are available to meet increased performance demands.	1 2 3 4 5
Technical Equipment - Distribution		**Level**
Supply and disposal network	Potential to supply utilities to any building point without affecting other systems (e.g., ceiling, basement, or floor conduits).	1 2 3 4 5
Media grid	Defined grid spacing for utility installations.	1 2 3 4 5
Reserve	Reserve capacity for utility expansion (e.g., cables or conduits).	1 2 3 4 5
Accessibility	Utilities are accessible and not embedded in ground or concrete, using surface-mounted or structural setups.	1 2 3 4 5
Structure	Use of standardized modules for utility supply and disposal (e.g., electrical tubes or flexible pipes).	1 2 3 4 5
Locking directions	Capability to isolate utility supply for specific uses (e.g., medical or non-medical).	1 2 3 4 5
Labeling	Unified labeling of utilities, including flow direction.	1 2 3 4 5
Type of connections	Standardized and user-friendly utility and data connections (e.g., quick couplings or plugs).	1 2 3 4 5
Documentation	Clear, multilingual manual, always accessible, with visible nameplate for key info.	1 2 3 4 5
Information Technology		**Level**
Network availability at workstations	Adequate network connections are available at all workstations.	1 2 3 4 5
Network availability in common areas	WLAN network connections are available in communal areas (e.g., meeting rooms, lounges, break rooms, cafeterias).	1 2 3 4 5
Software availability	Necessary software is installed at every workstation.	1 2 3 4 5
Software consolidation	Software is consolidated hospital-wide and limited to essential applications.	1 2 3 4 5
Roaming user concept	User profiles are automatically available via roaming when logging in at another workstation.	1 2 3 4 5
Workstation computer mobility	Proportion of laptops used as workstation computers.	1 2 3 4 5
Network access for mobile computers	Mobile devices can connect to the network from any required location (IP addresses in all subnets).	1 2 3 4 5
Telecommunication mobility	Employees can easily transfer their phone numbers when changing workstations.	1 2 3 4 5
Server scalability	Expandable and reducible computing power (e.g., blade technology or grid computing).	1 2 3 4 5
Data storage scalability	Expandable and reducible storage capacity through independent systems.	1 2 3 4 5
Network scalability	Scalability of active network components (e.g., switches, routers).	1 2 3 4 5

IT architecture	Functions are implemented in independent and standardized software modules.	1 2 3 4 5
IT-based decision support in the workplace	Tasks, especially in patient care and treatment, are supported on-screen.	1 2 3 4 5
Software	Use of standardized software (e.g., Microsoft Office, SAP) with no special solutions.	1 2 3 4 5
Data formats	Use of standardized data formats.	1 2 3 4 5
Interfaces	Use of open and documented interfaces (e.g., SOAP).	1 2 3 4 5
Type of connections	Standardized and user-friendly utility and data connections (e.g., quick couplings or plugs).	1 2 3 4 5
Storage Equipment		**Level**
Application flexibility	Ability to store current and planned goods without retrofitting.	1 2 3 4 5
Nominal load-bearing capacity	Nominal load capacity of the storage medium ensures flexibility.	1 2 3 4 5
Standardisation of storage resources	All storage systems are standardized and interchangeable.	1 2 3 4 5
Standardisation of storage aids	All storage aids are standardized and interchangeable.	1 2 3 4 5
Automatability	Ability to automate individual modules or the entire system or revert to manual operation.	1 2 3 4 5
Stack height	Number of storage levels is 5 or more.	1 2 3 4 5
Degree of connectivity	The system is securely connected to the floor, ceiling, or structure for stability.	1 2 3 4 5
Transportability	Basic transportability and necessary transport tools are in place.	1 2 3 4 5
Ease of assembly and disassembly	Ease of assembly and disassembly for improved mobility.	1 2 3 4 5
Degree of automation	Fully automated storage system.	1 2 3 4 5
Stock reserve	Storage reserves through unused shelves or extendable shelf height (not additional floor space).	1 2 3 4 5
System architecture	Functions implemented in independent and standardized modules.	1 2 3 4 5
Usability	Easy operation after a brief introduction, facilitating operator changes.	1 2 3 4 5
Documentation	Clear, multilingual manual, always accessible, with visible nameplate for key info.	1 2 3 4 5
Electrical supply	The central unit supports flexible and adaptable power connections.	1 2 3 4 5
Pneumatic and hydraulic supply	Adapt to internal or external supply and varying performance demands.	1 2 3 4 5
Provision of additional media	Differentiation of media supply needs, whether external supply is required.	1 2 3 4 5

Type of connections	Standardized and user-friendly utility and data connections (e.g., quick couplings or plugs).	1 2 3 4 5
Number of connections	Minimal connections for quick setup (e.g., power and compressed air).	1 2 3 4 5
Software interfaces	Standardized software interfaces for system integration (Plug & Produce).	1 2 3 4 5
Connection flexibility	High connection flexibility with adjustable connectors and adaptable interfaces.	1 2 3 4 5
Commissioning	Quick commissioning during changes with diagnostic capabilities (self-tests) and pre-checks.	1 2 3 4 5
Width	The system's width ensures adaptability for transport and modularity.	1 2 3 4 5
Length	The system's length ensures adaptability for transport and modularity.	1 2 3 4 5
Height	The system's height ensures adaptability for transport and modularity.	1 2 3 4 5
Weight	The system's weight ensures adaptability for transport and modularity.	1 2 3 4 5
Transportation Equipment		**Level**
Application flexibility	Ability to store current and planned goods without retrofitting.	1 2 3 4 5
Nominal load-bearing capacity	Nominal load capacity of the storage medium ensures flexibility.	1 2 3 4 5
Standardization of transport means	All transport systems are standardized and interchangeable.	1 2 3 4 5
Standardization of transport aids	All transport aids are standardized and interchangeable.	1 2 3 4 5
Deployment location	Usability of the transport system both indoors and outdoors.	1 2 3 4 5
Automatability	Ability to automate individual modules or the entire system or revert to manual operation.	1 2 3 4 5
Degree of connectivity	The system is securely connected to the floor, ceiling, or structure for stability.	1 2 3 4 5
Degree of automation	Fully automated storage system.	1 2 3 4 5
System architecture	Functions implemented in independent and standardized modules.	1 2 3 4 5
Usability	Easy operation after a brief introduction, facilitating operator changes.	1 2 3 4 5
Documentation	Clear, multilingual manual, always accessible, with visible nameplate for key info.	1 2 3 4 5
Electrical supply	The central unit supports flexible and adaptable power connections.	1 2 3 4 5
Pneumatic and hydraulic supply	Adapt to internal or external supply and varying performance demands.	1 2 3 4 5
Provision of additional media	Differentiation of media supply needs, whether external supply is required.	1 2 3 4 5

Type of connections	Standardized and user-friendly utility and data connections (e.g., quick couplings or plugs).	1 2 3 4 5
Number of connections	Minimal connections for quick setup (e.g., power and compressed air).	1 2 3 4 5
Software interfaces	Standardized software interfaces for system integration (Plug & Produce).	1 2 3 4 5
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Height	The system's height ensures adaptability for transport and modularity.	1 2 3 4 5
Weight	The system's weight ensures adaptability for transport and modularity.	1 2 3 4 5
Treatment Technology		**Level**
Special requirements	The system has no special requirements, ensuring full compatibility with operational needs.	1 2 3 4 5
Insensitivity	The system is fully resistant to vibrations, temperature, noise, and contamination.	1 2 3 4 5
Technology flexibility	Potential to perform various treatments with the technology.	1 2 3 4 5
Emission	The system does not emit vibrations, temperature, noise, or contamination.	1 2 3 4 5
Flexible commitments	Parallel development of competing technologies to adopt the more promising one during advancements.	1 2 3 4 5
Equipment for Non-Medical Services		**Level**
Application flexibility	Ability to store current and planned goods without retrofitting.	1 2 3 4 5
Standardization	All systems are standardized and interchangeable.	1 2 3 4 5
Automatability	Ability to automate individual modules or the entire system or revert to manual operation.	1 2 3 4 5
Degree of connection	Presence of a connection between the system and the floor, including its type.	1 2 3 4 5
Transportability	Basic transportability and necessary transport tools are in place.	1 2 3 4 5
Load-bearing capacity	System is self-supporting or includes a supporting frame.	1 2 3 4 5
Media lines and cabling	Media lines and cabling are efficient, reliable, and conform to all standards.	1 2 3 4 5
System architecture	Functions implemented in independent and standardized modules.	1 2 3 4 5

Usability	Easy operation after a brief introduction, facilitating operator changes.	1 2 3 4 5
Documentation	Clear, multilingual manual, always accessible, with visible nameplate for key info.	1 2 3 4 5
Electrical supply	The central unit supports flexible and adaptable power connections.	1 2 3 4 5
Pneumatic and hydraulic supply	Adapt to internal or external supply and varying performance demands.	1 2 3 4 5
Provision of additional media	Differentiation of media supply needs, whether external supply is required.	1 2 3 4 5
Type of connections	Standardized and user-friendly utility and data connections (e.g., quick couplings or plugs).	1 2 3 4 5
Number of connections	Minimal connections for quick setup (e.g., power and compressed air).	1 2 3 4 5
Standardized software interfaces	Standardized software interfaces for system integration (Plug & Produce).	1 2 3 4 5
Connection flexibility	High connection flexibility with adjustable connectors and adaptable interfaces.	1 2 3 4 5
Commissioning	Quick commissioning during changes with diagnostic capabilities (self-tests) and pre-checks.	1 2 3 4 5
Ease of assembly and disassembly	Ease of assembly and disassembly for improved mobility.	1 2 3 4 5
Width	The system's width ensures adaptability for transport and modularity.	1 2 3 4 5
Length	The system's length ensures adaptability for transport and modularity.	1 2 3 4 5
Height	The system's height ensures adaptability for transport and modularity.	1 2 3 4 5
Weight	The system's weight ensures adaptability for transport and modularity.	1 2 3 4 5
Equipment for Medical Services		**Level**
Application flexibility	Ability to store current and planned goods without retrofitting.	1 2 3 4 5
Standardization	All systems are standardized and interchangeable.	1 2 3 4 5
Automatability	Ability to automate individual modules or the entire system, or revert to manual operation.	1 2 3 4 5
Special requirements	The system has no special requirements, ensuring full compatibility with operational needs.	1 2 3 4 5
Insensitivity	The system is fully resistant to vibrations, temperature, noise, and contamination.	1 2 3 4 5
Emission	The system does not emit vibrations, temperature, noise, or contamination.	1 2 3 4 5
Width	The system's width ensures adaptability for transport and modularity.	1 2 3 4 5
Length	The system's length ensures adaptability for transport and modularity.	1 2 3 4 5

Height	The system's height ensures adaptability for transport and modularity.	1 2 3 4 5
Weight	The system's weight ensures adaptability for transport and modularity.	1 2 3 4 5
Degree of connectivity	The system is securely connected to the floor, ceiling, or structure for stability.	1 2 3 4 5
Transportability	Basic transportability and necessary transport tools are in place.	1 2 3 4 5
Load-bearing capacity	System is self-supporting or includes a supporting frame.	1 2 3 4 5
Means of transportation	Hospital provides a transport system for moving the equipment.	1 2 3 4 5
System architecture	Functions implemented in independent and standardized modules.	1 2 3 4 5
Usability	Easy operation after a brief introduction, facilitating operator changes.	1 2 3 4 5
Documentation	Clear, multilingual manual, always accessible, with visible nameplate for key info.	1 2 3 4 5
Electrical supply	The central unit supports flexible and adaptable power connections.	1 2 3 4 5
Provision of additional media	Differentiation of media supply needs (internal vs. external supply).	1 2 3 4 5
Type of connections	Standardized and user-friendly utility and data connections (e.g., quick couplings or plugs).	1 2 3 4 5
Number of connections	Minimal connections for quick setup (e.g., power and compressed air).	1 2 3 4 5
Software interfaces	Standardized software interfaces for system integration (Plug & Produce).	1 2 3 4 5
Connection flexibility	High connection flexibility with adjustable connectors and adaptable interfaces.	1 2 3 4 5
Commissioning	Quick commissioning during changes with diagnostic capabilities (self-tests) and pre-checks.	1 2 3 4 5
Ease of assembly and disassembly	Ease of assembly and disassembly for improved mobility.	1 2 3 4 5

Table A-2

Property		**Level**
Slope	The property has an ideal slope for maximum usability.	1 2 3 4 5
Obstacles	The property is completely free of physical obstacles like rivers, roads, or bridges.	1 2 3 4 5
Soil and rock class	The soil and rock are perfectly suited for construction and operational needs.	1 2 3 4 5
Legal and political restrictions	The environmental conditions are optimal for sustainable development.	1 2 3 4 5
Expansion area	The property is completely free for any further expansions.	1 2 3 4 5

Directions of growth	Number of non-overlapping growth directions.	1 2 3 4 5
Access	Property access sufficient for all development stages, with potential for expansion (e.g., multiple driveways).	1 2 3 4 5
Supply and disposal	Supply and disposal systems (e.g., media, information) sufficient and expandable for all development stages.	1 2 3 4 5
Geometry	Simple construction possible based on growth area geometry.	1 2 3 4 5
General Construction		**Level**
Obstacles	The property is completely free of physical obstacles like rivers, roads, or bridges.	1 2 3 4 5
Growth areas and directions	Grid layout considers growth directions, with buildings arranged along transformation axes and adjacent to growth areas.	1 2 3 4 5
Access	Transport connections to and from the property are seamless and highly efficient.	1 2 3 4 5
Supply and waste management	Supply and disposal systems (e.g., media, information) are sufficient and expandable for all development stages.	1 2 3 4 5
Zoning	A modular land zoning concept allows zones to be interchanged as needed.	1 2 3 4 5
Outdoor Facilities		**Level**
Building structure	All structures (e.g., fence elements, shelters) are standardized and interchangeable.	1 2 3 4 5
Foundation	The foundation design significantly impacts mobility, transferring loads from the structure to the ground.	1 2 3 4 5
Structure	Modular, standardized construction of structures (e.g., stelcon plates for parking lots).	1 2 3 4 5
Proportion of greenery	Proportion of outdoor areas with existing vegetation (excluding grass).	1 2 3 4 5
Type of greenery	Existing vegetation allows for easy construction without requiring replanting or tree removal permits.	1 2 3 4 5
Impression		**Level**
Clarity of lines and shapes	Clear lines and shapes create a simple and organized outdoor layout.	1 2 3 4 5
Simplicity	The outdoor area is functional and avoids unnecessary elements like decorations.	1 2 3 4 5
Proportionality	Elements are proportionally designed regarding dimensions (e.g., path lengths, rest areas).	1 2 3 4 5
Coloring	The outdoor area’s color scheme is simple, avoiding trendy or striking colors.	1 2 3 4 5
Layout		**Level**
Number of fixed points	Number of fixed points in the layout (e.g., column grids, load-bearing walls, or MRI), is low.	1 2 3 4 5
Area of fixed points	Percentage of fixed-point areas in the total layout (e.g., ramps, stairs, elevators, fire protection elements).	1 2 3 4 5
Location of fixed points	Three zones for fixed points: along transformation axes, at edges, or in central areas.	1 2 3 4 5

Area of additional restrictive zones	Percentage of restrictive areas in the layout (e.g., sensitive equipment placed away from heavy machinery).	1 2 3 4 5
Growth areas	Percentage of growth areas within buildings in the total layout.	1 2 3 4 5
Consideration of growth areas and axes	Arrangement of growth zones along axes with material flow perpendicular to expansion direction.	1 2 3 4 5
Area modules	Area dimensions based on modular catalog, aligned with building module lengths or multiples.	1 2 3 4 5
Structure areas	Standardized arrangement of spaces for similar purposes (e.g., buffers, maintenance).	1 2 3 4 5
Compactness of layout	Compact arrangement of all spaces with no fragmentation or unnecessary free areas.	1 2 3 4 5
Arrangement of similar functions	Spaces for similar functions should be located near each other to ensure efficient exchange.	1 2 3 4 5
Areas of deinstallation and reinstallation	Adequate dimensions for medical and non-medical spaces to support quick assembly/disassembly.	1 2 3 4 5
Cubature		**Level**
Floors	Number of above-ground floors.	1 2 3 4 5
Standardization	Cubature is standardized and interchangeable.	1 2 3 4 5
Building base module	Consistent building module dimensions for all measurements.	1 2 3 4 5
Bearing Structure		**Level**
Bearing capacity of the foundation	Load-bearing capacity of the foundation or ceiling structure.	1 2 3 4 5
Load capacity of floor and roof structures	Load-bearing capacity of floor slabs and the roof.	1 2 3 4 5
Load reserve	Percentage reserved as a load-bearing reserve.	1 2 3 4 5
Grid spacing of supports in the longitudinal direction	Spacing between supports along the length.	1 2 3 4 5
Grid spacing of supports in the transverse axis	Spacing between supports across the width.	1 2 3 4 5
Load-bearing walls	No load-bearing walls; support structures are used instead.	1 2 3 4 5
Clear height	Room height without interruptions from beams, substructures, or lights.	1 2 3 4 5
Ease of assembly and disassembly	Ease of assembly and disassembly for better mobility.	1 2 3 4 5
Scalability in the plane	Potential to expand or reduce the structure (supports and beams) without interrupting hospital operations.	1 2 3 4 5
Scalability of floors	Potential to add or reduce floors in the building without interrupting hospital operations.	1 2 3 4 5

Support grid structure	Uniform support grid throughout the hospital, based on the building's modular grid.	1 2 3 4 5
Structure	Structure composed of standardized modular components.	1 2 3 4 5
Joining technology	Simple module connection techniques without specialized tools (e.g., screws or plugs).	1 2 3 4 5
Building Envelope		**Level**
Openings and gates	Adequately sized, standardized openings and gates for introducing new medical or non-medical equipment.	1 2 3 4 5
Subsequent openings and gates	Ability to include passages for media or personnel in walls.	1 2 3 4 5
Daylight	Daylight design ensures sufficient lighting for tasks requiring high light levels (e.g., light domes).	1 2 3 4 5
Ease of assembly and disassembly	Ease of assembly and disassembly for better mobility.	1 2 3 4 5
Scalability framework	Potential to expand or reduce the shell without interrupting hospital operations.	1 2 3 4 5
Structure	Structure composed of standardized modular components.	1 2 3 4 5
Joining technology	Simple module connection techniques without specialized tools (e.g., screws or plugs).	1 2 3 4 5
Interior Finishing		**Level**
Floor condition	The property has an ideal slope for maximum usability.	1 2 3 4 5
Uniformity of floor covering	The floor in the hospital maintains consistent load-bearing capacity and durability.	1 2 3 4 5
Load capacity of floor covering	Load-bearing capacity of the flooring.	1 2 3 4 5
Floor markings	Potential to modify floor markings in the hospital.	1 2 3 4 5
Ease of assembly and disassembly	Ease of assembly and disassembly for better mobility.	1 2 3 4 5
Structure	Structure composed of standardized modular components.	1 2 3 4 5
Joining technology	Simple module connection techniques without specialized tools (e.g., screws or plugs).	1 2 3 4 5
Furniture		**Level**
Ergonomics	Potential to adapt workstations to ergonomic needs (e.g., height-adjustable desks).	1 2 3 4 5
Standardization	Furniture is standardized and interchangeable.	1 2 3 4 5
Special requirements	Furniture has no special requirements for fire protection or occupational safety.	1 2 3 4 5
Insensitivity	Furniture is resistant to vibrations, temperature, noise, and contamination.	1 2 3 4 5
Width	The furniture's width ensures adaptability for transport and modularity.	1 2 3 4 5
Length	The furniture's length ensures adaptability for transport and modularity.	1 2 3 4 5

Hight	The furniture's height ensures adaptability for transport and modularity.	1 2 3 4 5
Weight	The furniture's weight ensures adaptability for transport and modularity.	1 2 3 4 5
Degree of connectivity	Connection of furniture to the floor and its type.	1 2 3 4 5
Ease of assembly and disassembly	Ease of assembly and disassembly for better mobility.	1 2 3 4 5
Transportability	Transport connections to and from the property are seamless and highly efficient.	1 2 3 4 5
Load-bearing capacity	Furniture is a self-supporting structure or includes a supporting frame.	1 2 3 4 5
Means of transportation	Transport connections to and from the property are seamless and highly efficient.	1 2 3 4 5
System architecture	Functions of furniture are implemented in independent and standardized modules for scalability.	1 2 3 4 5
Electrical supply	Central requirements for connection power.	1 2 3 4 5
Provision of additional media	Distinguishing whether furniture requires external media supply.	1 2 3 4 5
Work Station Design		**Level**
Lighting conditions	Potential to ensure high-light-demand tasks can be performed year-round using a combination of natural and artificial light.	1 2 3 4 5
Climate	Potential to create different climates (temperature and humidity) in building zones year-round.	1 2 3 4 5
Flooring load capacity	Load capacity of the flooring.	1 2 3 4 5

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Biography

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