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Cost Calculations Based on Different Economic Sectors

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Abstract

The COSYMA program system for evaluating the off-site consequences of accidental releases of radioactive material to the atmosphere includes an ECONOMICS module for assessing economic consequences. The aim of this module is to convert various consequences (radiation-induced health effects and impacts resulting from countermeasures) caused by an accident into the common framework of economic costs; this allows different effects to be expressed in the same terms and thus to make these effects comparable.

With respect to the countermeasure "movement of people", the dominant cost categories are "loss-of-income costs" and "costs of lost capital services". In the original version of the ECONOMICS module these costs are calculated on the basis of the total number of people moved. In order to take into account also regional or local economic peculiarities of a nuclear site, the ECONOMICS module has been extended: calculation of the above mentioned cost categories is now based on the number of employees in different economic sectors in the affected area. This extension of the COSYMA ECONOMICS module is described in more detail.

Erweiterung des COSYMA - ECONOMICS Moduls
Kostenrechnungen mit verschiedenen Wirtschaftssektoren

Das Programmsystem COSYMA zur Abschätzung der Folgen von Freisetzungen von radioaktivem Material in die Atmosphäre in der Umgebung einer kerntechnischen Anlage enthält einen ECONOMICS-Modul zur Bestimmung der volkswirtschaftlichen Auswirkungen. Mit diesem Modul lassen sich verschiedenartige Effekte (strahleninduzierte Gesundheitsschäden sowie die Auswirkungen von Schutz- und Gegenmaßnahmen) in volkswirtschaftliche Kosten umrechnen; auf diese Weise können diese Effekte in gleichen Einheiten ausgedrückt und damit vergleichbar gemacht werden.

Im Falle von "Umsiedlung von Personen" als Schutz- und Gegenmaßnahme sind die bestimmenden Kostenkategorien "Produktionsausfall" bzw. "Verlorene Kapitalnutzung". In der ursprünglichen Version des ECONOMICS-Moduls werden diese Kosten auf der Basis der insgesamt umgesiedelten Personen bestimmt. Um jedoch auch regionale bzw. lokale wirtschaftliche Besonderheiten in der Umgebung einer kerntechnischen Anlage in Betracht ziehen zu können, ist der ECONOMICS-Modul erweitert worden: die Berechnung der genannten Kostenkategorien basiert nun auf der Anzahl der Beschäftigten in verschiedenen Wirtschaftsbereichen im betroffenen Gebiet. Diese Erweiterung des ECONOMICS-Moduls in COSYMA wird näher beschrieben.

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1. Introduction

The COSYMA program system for evaluating the off-site consequences of accidental releases of radioactive material to the atmosphere includes an ECONOMICS module for assessing the off-site **economic consequences**. The aim of this module is to convert various consequences caused by an accident into the common framework of **economic costs**; this allows different effects to be expressed in the same terms and thus to make these effects comparable. A detailed description of the model philosophy applied in the ECONOMICS module as well as the calculational procedure, and the input values to be provided by the user are given in /1/.

The primary consequences that are treated in COSYMA are radiation-induced health effects (non-fatal and fatal) in the population; secondary consequences result from countermeasures taken to reduce the number of these health effects. These countermeasures include e.g. the movement of people from areas with too high levels of radiation exposure (evacuation and relocation), or the decontamination of land and buildings, or restrictions on the production of agricultural products in contaminated areas and on the distribution of contaminated food.

With respect to the "movement of people" countermeasure, the dominant cost categories in calculating economic consequences are "loss-of-income costs" and "costs of lost capital services". In the original version of the ECONOMICS module these costs are calculated on the basis of the total number of **people** moved - together with the respective unit cost values **per capita**.

The ECONOMICS module has been extended in order to take into account also regional or local economic peculiarities of a nuclear site. In this extended version, calculation of loss-of-income costs and costs of lost capital services is based on the number of **employees** in different **economic sectors** (instead of the total number of people) in the evacuation or relocation area; the corresponding unit cost values have to be provided in this case on a **per-employee** basis.

Comparative calculations have shown that the advantage of the new procedure is evident for small areas of evacuation or relocation, or if only one single weather sequence is considered. On the other hand, the larger the affected areas become, the more the local peculiarities of the economic situation tend to level out compared with the nation-wide average. Therefore, the extended version has been implemented only for the near-range versions of COSYMA, i.e. NE (evacuation) and NL (relocation). It has not been regarded as reasonable to extend the FL version because in that case large relocation areas would be considered by definition.

In the following chapters the extension of the ECONOMICS module will be described in more detail. The description relates to the original version and aims at showing the differences; therefore it is indispensable that the reader is familiar with the main report /1/, the more so since cross-references are frequently made.

In Chapter 2., the calculational procedure will be described which is applied to loss-of-income costs and costs of lost capital services on the basis of the number of employees in different economic sectors. Chapter 3. contains the user input parameters and describes additional statistical data processing in more general terms which is necessary in that kind of cost calculations. In Chapter 4., an input example will be presented. Finally, in Chapter 5., the input-output procedures for processing the additional statistical data will be described in more detail.

The extended version of the ECONOMICS module has been implemented in the overall COSYMA program system, version 93/2 (which is available to users on request), and it will be implemented in the following versions.

2. Description of the Calculational Procedure

2.1 General Modelling

The fundamental procedure applied to calculate loss-of-income costs and costs of lost capital services during each period of time N according to the original version is the following (see /1, p. 13/):

Loss-of-income costs (evacuation/relocation):

$C\text{-}LOI_N$ = number of people affected during each period of time N (cap)
- Gross Domestic Product (M.U.*/cap-year)
- duration of period of time N (years)

Costs of **lost capital services** (relocation only):

$C\text{-}LCS_N$ = number of people affected during each period of time N (cap)

$\bullet \sum_{NN} \sum_{K=1}^{3}$ capital value of component K in the year NN (M.U./cap)
- (depreciation rate K + interest rate) (1/year)

+

area affected during each period of time N (m^2)

$\bullet \sum_{NN}$ capital value of land (K = 4) in the year NN (M.U./m^2)
- (depreciation rate "land" + interest rate) (1/year)

whith NN = years within period of time N.

Note:
The costs of lost capital services are split into K = 4 components: (1) non-residential capital, (2) houses and buildings, (3) consumer durables, and (4) land. Of these, (1) and (2) are assigned to economic production; both categories can therefore be split into economic sectors and treated on the basis of the number of employees. (3) is assigned to private capital, and the only (and reasonable) method of calculation refers to the total number of people as a basis; (4) is calculated on the area of land as the basis.

This leads to an extended version of the ECONOMICS module, in which the equations mentioned above are subjected to the following changes:

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*) M.U. = monetary unit, for more details see explanations at the beginning of Chapter 3.

Loss-of-income costs (evacuation/relocation):

$$C\text{-}LOI_N = \sum_{NES} \text{number of employees in economic sector NES in the affected area during each period of time N (empl)} \cdot \text{Gross Domestic Product of economic sector NES (M.U./empl-year)} \cdot \text{duration of period of time N (years)}$$

Costs of **lost capital services** (relocation only):

$$C\text{-}LCS_N = \sum_{NES} \text{number of employees in economic sector NES in the affected area during each period of time N (empl)} \cdot \sum_{NN} \sum_{K=1}^{2} \text{capital value of component K in the year NN (M.U./empl)} \cdot \text{(depreciation rate K + interest rate) (1/year)}$$

$$+$$

$$\text{number of people affected during each period of time N (cap)} \cdot \sum_{NN} \text{capital value of component K = 3 in the year NN (M.U./cap)} \cdot \text{(depreciation rate K + interest rate) (1/year)}$$

$$+$$

$$\text{area affected during each period of time N (m}^2\text{)} \cdot \sum_{NN} \text{capital value of land (K = 4) in the year NN (M.U./m}^2\text{)} \cdot \text{(depreciation rate "land" + interest rate) (1/year)}$$

2.2 *Extended Calculation in the NE Version (Evacuation)*

A detailed description of the calculation of **loss-of-income** costs carried out in the EVACOS submodule of the NE version is described in /1, p. 34/. For extended modelling the respective equation reads:

$$CEVLOI = \sum_{NES} EVEMP_{NES} \cdot \mathit{UCLOI4}_{NS,NES} \cdot (DUREV/365)$$

where

CEVLOI = loss-of-income costs (M.U.),

$EVEMP_{NES}$ = number of employees of economic sector NES in the evacuation area (empl),

$\mathit{UCLOI4}_{NS,NES}$ = unit costs of loss-of-income in economic sector NES at nuclear site NS (M.U./empl-year),

DUREV = *ITBACK* = duration of evacuation (days).

Notes:

(1) All user input data are indicated in *ITALICS*.

(2) Assigning the indices NES to economic sectors will be explained in Chapter 3.2.

(3) $EVEMP_{NES}$ is precalculated in subroutine EVAREG with the help of KENNAB, a flag for each grid element in the COSYMA r,ϕ-grid that indicates whether or not the grid element belongs to the evacuation area. For this precalculation, an additional data file EMP is necessary that contains the number of employees in different economic sectors for each grid element and each nuclear site considered. The generation of this data file EMP will be described in more detail in Chapter 5.
(4) The derivation of *UCLOI4* will be explained in Chapter 3.2.

EVEMP in subroutine EVAREG is calculated for each nuclear site NS (and each weather sequence) as follows:

For each economic sector NES:
For all grid elements (from J = 1 to *JMAX* and I = 1 to *IREMP* for which $KENNAB_J = 1$ or = 2):

$$EVEMP_{NES} = \sum EMP_{J,I,NES,NS}$$

Note:
EVEMP is calculated only up to a radius R = RA(*IREMP*), with *IREMP* being a user input, *IREMP* $\leq$ *IMAX*. This restriction in area has been introduced in order to allow the user to make cost calculations with the extended version even in the case that the availability of statistical data is limited in area. For the case *IREMP* < *IMAX*, an additional steering parameter *IEMP* allows the user to decide whether or not he wants to carry out cost calculations outside the area R = RA(*IREMP*) using the reference method (see also description of *IREMP* and *IEMP* in Chapter 3.1).

2.3 *Extended Calculation in the NL Version (Relocation)*

A detailed description of the calculation of **loss-of-income** costs and costs of **lost capital services** carried out in the RELCOS submodule of the NL version is described in /1, p. 38 ff./. For extended modelling, the respective equations read:

Loss-of-income costs:

$$CRLLI_N = \sum_{NES} ERLS_{NES,N} \cdot UCLOI4_{NS,NES} \cdot TIVA4_{NES,N}$$

where

$CRLLI_N$ = loss-of-income-costs during each period of time N (M.U.),
$ERLS_{NES,N}$ = number of employees of economic sector NES in the relocation area during each period of time N (empl),

$UCLOI4_{NS,NES}$ = unit costs of loss-of-income in economic sector NES at nuclear site NS (M.U./empl-year),

$TIVA4_{NES,N}$ = time-integrated value for each economic sector NES (year), includes duration of each period of time N and discounting, calculated in the DISCO subroutine.

Costs of **lost capital services (LCS)**:

$$CRLLC_N = \sum_{NES} \sum_{K=1}^{2} ERLS_{NES,N} \cdot UCCAP4_{NS,K,NES} \cdot TIDP4_{K,NES,N}$$

$$+ ERLS_{1,N} \cdot UCCAP1_{NS,3} \cdot TIDP2_{3,N}$$

$$+ ARLS1_N \cdot UCLAN1_{NS} \cdot TIDP2_{4,N}$$

where

$CRLLC_N$ = costs of LCS during each period of time N (M.U.),

$ERLS_{NES,N}$ = number of employees of economic sector NES, in the relocation area during each period of time N (empl),

$ERLS_{1,N}$ = number of people relocated during each period of time N (cap),

$ARLS1_N$ = area relocated during each period of time N (m^2),

$UCCAP4_{NS,K,NES}$ = unit costs of LCS in economic sector NES at nuclear site NS, for K = 1 to 2 (M.U./empl),

$UCCAP1_{NS,3}$ = site-specific unit costs of LCS (K=3), (M.U./cap),

$UCLAN1_{NS}$ = site-specific unit costs of LCS (K=4) (M.U./m^2),

$TIDP4_{K,NES,N}$ = time-integrated value for each economic sector NES for K = 1 to 2 (-); includes depreciation and discounting during each year of period of time N, calcul. in the DISCO subroutine,

$TIDP2_{3,N}$ = like TIDP4, no dependency on NES, K=3, calculated in DISCO,

$TIDP2_{4,N}$ = like TIDP4, no dependency on NES, K=4, calculated in DISCO.

Notes:

(1) All user input data are indicated in *ITALICS*.

(2) Assigning the indices NES to economic sectors will be explained in Chapter 3.2.

(3) $ERLS_{NES,N}$ is precalculated in subroutine RELREG with the help of KENNC, a flag for each grid element in the COSYMA r,ϕ-grid that indicates whether or not the grid element belongs to the relocation area - the value of KENNC is the index of the period of time in which relocation ends. For this precalculation, an additional data file EMP is necessary that contains the number of employees in different economic sectors for each grid element and each nuclear site considered. The generation of this data file EMP will be described in more detail in Chapter 5.

(4) The derivation of *UCLOI4* and *UCCAP4* will be explained in Chapter 3.2. *UCCAP1* and *UCLAN1* are unit cost values to be used in the reference version.

(5) The calculation of TIVA4 in subroutine DISCO is similar to that of TIVA, that of TIDP4 is similar to that of TIDP2, as described in the main report /1, p.30/. The dependency of

TIVA4 and TIDP4 on economic sectors NES is due to the fact that the recovery time has been introduced in the extended version as dependent on NES. This means that the point in time until which loss-of-income costs are calculated and from which the calculation of the costs of lost capital services (for components K = 1 to 2) starts, may be different for each economic sector NES.

ERLS in subroutine RELREG is calculated for each nuclear site NS (and each weather sequence) as follows:

For each economic sector NES:
For all grid elements (from J = 1 to *JMAX* and I = 1 to *IREMP* for which $KENNC_J > 0$:
For all grid elements (J,I) with identical values $KENNC_J$
(with $KENNC_J$ ranging from N = 1 to *NNT*):

$$ERLS_{NES,N} = ERLS_{NES,\ KENNC_J} = \sum EMP_{J,I,NES,NS}$$

The calculation of ARLS1 (which is not dependent on NES) is similar to that of ERLS:

$$ARLS1_N = ARLS1_{KENNC_J} = \sum FLAND_{J,I,NS}$$ with FLAND: see /1, p.41/.

Note:
ERLS and ARLS1 are calculated only up to a radius R = RA(*IREMP*), with *IREMP* being a user input, $IREMP \leq IMAX$. This restriction in area has been introduced in order to allow the user to make cost calculations with the extended version, even in the case that the availability of statistical data is limited in area. For the case $IREMP < IMAX$, an additional steering parameter *IEMP* allows the user to decide whether or not he wants to carry out cost calculations outside the area R = RA(*IREMP*) using the reference method (see also description of *IREMP* and *IEMP* in Chapter 3.1).

3. Additional Input Data

In this chapter, the user input data for the extended version will be described. The original values of the steering parameters ICEVA and ICREL have been extended - the new version has been introduced as **option 4**; all other parameters described below are new and will only be used if option 4 is selected.

In addition, it should be mentioned that the monetary unit (M.U.) used in ECONOM is not predetermined; it will be determined by the currency of the input costs and thus is subject to user input. For the following parameters describing unit costs, the default values (DV) are given in M.U. = 1 DM.

3.1 User Input Parameters

ICEVA (DV = 0): flag that controls calculation of evacuation costs; possible values: 0 = no calculation; if ICEVA > 0, the value consists of 3 digits, where the 1st digit refers to transport costs, the 2nd digit to accommodation costs, the 3rd digit to loss-of-income costs.

Values of transport costs: 1 or 4,
values of accommodation costs: 0 or 1 or 2 or 4,
values of loss-of-income costs: 1 or 2 or 3 or 4.

For transport costs:

1 = reference option,
4 = see below.

For accommodation and loss-of-income costs:

0 = no calculation,
1 = calculation with site-specific unit costs,
2 = calculation with region-specific unit costs,
3 = calculation with land-use cost,
4 = see below.

Additional option for loss-of-income costs:

4 = calculation with unit costs of different economic sectors. Note: In this case, the remaining cost categories will be calculated using the methodology of option 1; nevertheless, the exact calculation is different from the "real" option 1, as special population grid data are to be used, therefore, the overall flag to call option 4 is ICEVA = 444.

ICREL (DV = 0): flag that controls calculation of relocation costs; possible values: 0 = no calculation; if ICREL > 0, value consists of 4 digits, where the 1st digit refers

to transport costs, the 2nd digit to accommodation costs, the 3rd digit to loss-of-income costs, the 4th digit to lost capital services. In detail:

Values of transport costs: 1 or 2 or 4,
where:
- 1 = reference option,
- 2 = simplified calculation,
- 4 = see below.

Values of accommodation costs: 0 or 1 or 2 or 4,
values of loss-of-income costs: 1 or 2 or 3 or 4,
values of lost capital services: 1 or 2 or 4,
where:
- 0 = no calculation,
- 1 = calculation with site-specific unit costs,
- 2 = calculation with region-specific unit costs,
- 3 = calculation with land-use cost,
- 4 = see below.

Additional option for loss-of-income costs and costs of lost capital services:
- 4 = calculation with unit costs of different economic sectors. Note: In this case, the remaining cost categories will be calculated using the methodology of option 1; nevertheless, the exact calculation is different from the "real" option 1, as special population grid data are to be used, therefore, the overall flag to call option 4 is ICREL = 4444.

Notes:
For the calculation of accommodation and loss-of-income costs according to option 2, an additional data file has to be provided that assigns - for each nuclear site - each grid element (J,I) of the r,ϕ-grid to an economic region. This data file is read in on NUNITS(7) and has the format ((KRE(J,I),J = 1,JMAX),I = 1,IMAX). This data file is NOT INCLUDED in the overall COSYMA program package and has to be provided by the user if he selects option 2.

For the calculation of loss-of-income costs according to option 3 an additional data file has to be provided in which - for each nuclear site - the Gross Domestic Product (GDP) is given for the area of each grid element (J,I) of the r,ϕ-grid. This data file is read in on NUNITS(10) and has the format ((ARLOI(J,I),J = 1,JMAX),I = 1,IMAX). This data file is NOT INCLUDED in the overall COSYMA program package and has to be provided by the user if he selects option 3.

For the calculation of loss-of-income costs and costs of lost capital services according to option 4 an additional data file has to be provided in which - for each nuclear site - the number of employees in different economic sectors is given for each grid element (J,I) of the r,ϕ-grid. This data file is read in on NUNITS(20) and has - besides a header - the

format ((((EMP(J,I,NES,NS),J = 1,JMAX),I = 1,IMAX),NES = 1,NESEC),NS = 1,NSTMAX). This data file is NOT INCLUDED in the overall COSYMA program package and has to be provided by the user if he selects option 4. The population grid data to be used in this case for the calculation of transport and accommodation costs are included in EMP.

UCLOI4(NS,NES) (DV = 5 * 0., 5 * VAL.,
5 * 180800., 5 * 122400.,
5 * 77600., 5 * 86400.,
5 * 62800., 5 * 72300.,
5 * 54300., 5 * 91400.,
5 * 122200., 5 * 91000.,
5 * 65300., 10 * 0.,

where VAL. = 265300. for evacuation, VAL. = 97600. for relocation):
unit costs of loss-of-income for each economic sector NES (and each nuclear site NS), to be used for option 4 (M.U./empl-year). The default values are based on the Gross Domestic Product in each economic sector; for a detailed derivation from national economic statistics, see Chapter 3.2.

UCCAP4(NS,K,NES) (DV = 5 * 0., 5 * 54700., 5 * 240400., 5 * 359300.,
5 * 283500., 5 * 614000., 5 * 136100., 5 * 58400.,
5 * 57000., 5 * 32400., 5 * 52000., 5 * 29700.,
5 * 46000., 5 * 35400., 5 * 12500., 5 * 12900.,
5 * 17300., 5 * 51500., 5 * 96800., 5 * 163600.,
5 * 24500., 5 * 136600., 5 * 57800., 5 * 106700.,
5 * 13800., 5 * 132600., 20 * 0.):
unit costs of lost capital services for each economic sector NES (and each nuclear site NS), to be used for option 4 (M.U./empl) (K = 1: non-residential capital, K = 2: housing and buildings). The default values are based on capital investments in each economic sector; for the derivation from national economic statistics, see Chapter 3.2.

Note:
Although the main dependency of the parameters **UCLOI4** and **UCCAP4** is on the economic sectors NES, the dependency on the nuclear site NS has been kept in order to give the user the possibility to take into account in addition site-specific differences. On the other hand, it is recommended to the user to consider only one nuclear site (or two at the most) in one calculation because of the large amount of statistical data needed for this option.

IREMP (DV = 20): number of radial distances to be used for cost calculations in option 4, i.e. calculations are carried out up to a radius R = RA(IREMP).

IEMP (DV = 0): flag that controls cost calculations outside the area in which option 4 is applied:

0 = cost calculations according to option 4 up to R = RA(IREMP) using grid data "EMP", no cost calculations outside R = RA(IREMP),

1 = cost calculations according to option 4 up to R = RA(IREMP) using grid data "EMP", cost calculations using option 1 (together with the original population grid data) outside R = RA(IREMP).

TRESEC (DV = 0.0, 3.0, 6.0, 8.0, 3.0, 5.0, 2.0, 0.3, 0 .3, 2.0, 0.3, 0.3, 0.3, 2*0.0): "recovery time" (year). The meaning of this parameter is explained in more detail in /1, p. 10/. The default values are based on estimates.

3.2 Derivation of User Input Data from National Economic Statistics

The unit cost values UCLOI4 and UCCAP4 in option 4 for the calculation of loss-of-income costs, and costs of lost capital services, resp., are derived in a similar way as UCLOI1 and UCCAP1 for option 1 - see details in /1, p. 73. ff./. For the new base year 1991 the original data are /2/:

Gross Domestic Product (GDP) - to be used as a basis for **UCLOI4**:

(in 10^9 DM/year)	Base Year 1991
Total national economy:	
Gross Value Added	+ 2,428.9
(Production taxes - subsidies)	- 85.4
GDP (at factor costs)	= 2,343.5
Rent of houses:	
GDP (at factor costs)	- 172.5
	= 2,171.0
Agriculture (60 % of total sector)	
GDP (at factor costs)	- 23.0
	= 2,148.0

The economic sectors that are generally used in German national statistics are given in Table 3.1. It should be noted that Table 3.1 contains 10 main economic sectors ("0", "1", "2", etc.) whereas the main sector "2 - Manufacturing sector" is subdivided further into 9 subsectors ("20", "21", "22", etc.). The use of the subsectors instead of the main sector "2" leads to a total of 18 economic sectors that are available for the cost calculations in ECONOM.

Table 3.1: **Economic Sectors to Be Used in German National Statistics**

Code Number	Name of Economic Sector
0	Agriculture and forestry, fishery
1	Energy and water supply, mining
2	Manufacturing sector, subdivided into
20	- Chemical industry, mineral oil refining
21	- Plastics and rubber manufacture
22	- Mining and processing of non-metallic minerals
23	- Metal production and working
24	- Steel construction, mechanical engineering, vehicle construction, etc.
25	- Electrical and optical engineering
26	- Wood, paper and printing industries
27	- Leather, textile and garment industries
28	- Food and tobacco industries
3	Construction industry
4	Commerce and trade
5	Transport, telecommunications
6	Banking industry, insurance sector
7	Services sector
8	Non-profit organisations
9	Central, regional and local authorities, social insurance sector

The GDP values of 2,171.0 • 10^9 DM/year (i.e. without subtraction of the agricultural sector - to be used for evacuation in the NE version) and 2,148.0 • 10^9 DM/year (i.e. with subtraction of 60 % of the agricultural sector treated in food bans - to be used for relocation in the NL version) are broken down into the 18 economic sectors as shown in Table 3.2.

On the other hand, as can be seen from Table 3.2, in some cases economic sectors have been combined; this has been done where the specific GDP/employee values are similar and the values of the recovery time are the same. In this way, the original 18 economic sectors have been reduced to 12 new sectors. This reduction has been carried out in order to reduce the computing effort in the ECONOMICS module. In principle, it is of course possible to use all 18 sectors for the calculation - or to select other combinations. The procedure for this reduction will be explained in Chapter 5.4.

It should also be mentioned that NES = 1 has been assigned to the total population and is not used for calculation of loss-of-income costs.

Table 3.2: **GDP/Employee for Different Economic Sectors**

Index of NES	Code of Economic Sector	GDP (10^9 DM/year)	Number of Employees	GDP/Employee (DM/empl-year)	Time of Recovery (year)
1	(assigned to total population - not used here)				0.0
2	0	36.4*	137,226	265,300	3.0
	0	13.4**	137,226	97,600	3.0
3	1	72.6	401,584	180,800	6.0
4	20	70.1	572,968	122,400	8.0
5	21	31.6	382,074	82,700	3.0
	22	28.2	323,197	87,100	3.0
	26	58.8	823,821	71,500	3.0
		118.6	1,529,092	77,600	3.0
6	23	51.8	663,688	78,100	5.0
	24	222.1	2,518,772	88,200	5.0
	25	145.8	1,676,271	87,000	5.0
		419.7	4,858,731	86,400	5.0
7	27	26.5	607,156	43,800	2.0
	28	60.8	784,601	77,500	2.0
		87.3	1,391,757	62,800	2.0
8	3	133.8	1,851,652	72,300	0.3
9	4	218.5	4,028,741	54,300	0.3
10	5	141.3	1,547,283	91,400	2.0
11	6	118.0	965,469	122,200	0.3
12	7	435.0	4,784,493	91,000	0.3
13	8	61.4	1,165,655	52,600	0.3
	9	258.4	3,738,285	69,100	0.3
		319.8	4,903,940	65,300	0.3

*) to be used in case of evacuation
**) to be used in case of relocation

Capital investments - to be used as a basis for **UCCAP4**:

($in 10^9$ DM)	Base Year 1991	
	Non-residential	Housing/Buildings
Total national economy	+ 1,278.2	+ 5,746.6
Agriculture (60 % of total sector)	- 40.2	- 58.4
	= 1,238.0	= 5,688.2

The breakdown of capital investments into economic sectors is done in a similar way as that of GDP, the derivation is not shown in detail - the results are presented in Table 3.3.

Table 3.3: **Capital Investments/Employee for Different Economic Sectors**

Index of NES	Capital Investment/Employee Non-residential (NES=1: DM/cap, all others: DM/empl)	Housing/Buildings
1	0	54,700
2	240,400	359,300
3	283,500	614,000
4	136,100	58,400
5	57,000	32,400
6	52,000	29,700
7	46,000	35,400
8	12,500	12,900
9	17,300	51,500
10	96,800	163,600
11	24,500	136,600
12	57,800	106,700
13	13,800	132,600

It should be mentioned that in the case of capital investments the subsector "Rent of Houses" is assigned to NES = 1 and treated on the basis of the total population. It should also be noted that the capital values for K = 3 (consumer durables) and K = 4 (land) are not broken down into economic sectors; they are treated on the basis of the total population and are the same as in option 1. The respective unit costs are: for consumer durables = 18,000 DM/cap, and for land = 24 DM/m^2.

3.3 Establishment of Additional Data Files for the Cost Calculations

It is obvious that the use of option 4 in calculating evacuation or relocation costs calls for much efforts in processing the data originally available from national statistics in such a way that they can be used in the COSYMA program system.

The general procedure of data processing is the same as described in the COSYMA preprocessing program **GRIDS** (for more details of the input and output of this program, see the COSYMA USER GUIDE /3, Chapter VI./). When option 4 is used, it is not the number of people that are taken as key values for the cost calculations, but rather the number of employees in different economic sectors; however, the treatment of the data in GRIDS, although much more extensive, is the same.

The use of GRIDS leads to two major steps in data processing:

1) transfer of the originally available data into a form that they can be used as input for GRIDS,

2) transfer of the input data of GRIDS into a form that they can be used in COSYMA.

The primary statistical data used for the calculations have been taken from the National Census in the Federal Republic of Germany in 1987 /4/ - this means that only data of the "old" federal states are available; the former German Democratic Republic still existed at that time, but no comparable data are available for this country.

The original data available from the National Census in 1987 are: for each of the approximately 8,500 municipalities in Germany the numbers of employees of each of the 18 economic sectors (and the population) that are listed in Table 3.1. In addition, geographical information is available for each municipality on the centre and the borders (polygons) as well as on the settlement areas - all in x,y coordinates.

Software programs have been developed to transfer the information mentioned above into data sets of the following kind:

1) for the far range of a nuclear site a data set with about 25 km^2 resolution in geographic projection (i.e. longitude and lattitude). The basis for this 25 km^2 grid for Germany is the EUROPEAN GRID, which primarily consists of grid elements of a 10,000 km^2 grid area. By a 20-fold linear subdivision in x- and y-directions each primary grid element is subdivided into 400 elements of 25 km^2,

2) for the near range of each nuclear site considered a data set with 500 m x 500 m resolution up to a distance of about 25 km in UTM projection.

Both kinds of data sets have to be established for each of the 18 economic sectors and the population (i.e. 19 data sets). The data sets mentioned under 1) have been created - and are available on request - for the total area of the (old) Federal Republic of Germany - these data sets are independent of the nuclear sites considered. The data sets mentioned under 2) have been created only for two German nuclear sites as an example.

The next step in data processing is to transfer the data of each of the 19 sectors of the near range and the far range into a new data set with polar coordinates (r,ϕ-grid) with the help of the GRIDS program.

The final step in data processing is to transfer the 19 data sets in polar coordinates into one data set, with the possibility of combining at the same time two or more economic sectors into one according to the user's preference. This kind of combination has already

been shown in Tables 3.2 and 3.3, where the 18 economic sectors originally available have been reduced to 12.

A more detailed description of the inputs and outputs in each step of the transfer process is given as an Appendix in Chapter 5.

4. Input Example

The ECONOMICS module contains a submodule ECODAT, which is called at the beginning to check the steering parameters and to provide a printout of all ECONOM-specific input data used in that run (see /1, p. 27/ for more details). The printout of the input data for relocation and decontamination (version NL) in case of option 4 is shown on the next pages. The printout of the input data for evacuation (version NE) in case of option 4 is similar.

It should be mentioned that the use of option 4 in calculating relocation costs has also implications on decontamination costs, as decontamination in COSYMA is a measure related to relocation in the way that it is used to accelerate resettlement. This relation is due to area restrictions imposed by the parameters IREMP and IEMP. In other words: if e.g. IEMP = 0 and IREMP < IMAX which means that relocation costs are only calculated up to a radius R = RA(IREMP), this restriction in cost calculations is also applied to the calculation of decontamination costs. The same holds for other values of IREMP and IEMP.

```
*****  PROGRAM SYSTEM  C O S Y M A / N L  *****  PROGRAM UNIT  E C O N O M  *****  SUBROUTINE  E C O D A T  *****


COST CATEGORIES TO BE CALCULATED (IC... = 0 ==> NO COST CALCULATIONS, IC... > 0 ==> COST CALCULATIONS):

       SHELTERING COSTS:              ICSHE =    0
       RELOCATION COSTS               ICREL = 4444
       DECONTAMINATION COSTS:         ICDEC =    1
       FOOD BAN COSTS:                ICFOB =    0
       EARLY HEALTH EFFECTS COSTS:    ICEHE =    0
       LATE HEALTH EFFECTS COSTS:     ICLHE =    0


INPUT VALUES TO BE USED:
(ALL COST VALUES IN "MONETARY UNITS (M.U.)", 1 M.U. =  1 DM     )


   RELOCATION
   **********

   FACTOR TO ADJUST UNIT COSTS: FUCEC =  1.0000

      TRANSPORT COSTS            ACCOMMODATION COSTS        LOSS-OF-INCOME COSTS       COST OF LOST CAPITAL SERVICES
      ---------------            -------------------        --------------------       -----------------------------

      OPTION 4/(1)               OPTION 4/(1)               OPTION 4/(1)               OPTION 4/(1)

      NOTE: OPTION 4 IS USED FOR COST CALCULATIONS WITHIN THE AREA UP TO RADIUS RA(IREMP=16) =   42000. M,

      NUMBER OF ECONOMIC SECTORS TO BE USED IN THIS AREA: NESEC = 13 (WHEREAS NES = 1 IS ASSIGNED TO POPULATION DATA),

      IEMP =  1, I.E. COSTS ARE CALCULATED OUTSIDE THE AREA OF RA(IREMP) USING OPTION 1


   UNIT COSTS (ADJUSTED):

      PRIVATE/PUBLIC (M.U./CAP)
         URLTPR  =      60.
         URLTPU  =      60.

                                  UCACC1(NS)  (M.U./CAP-YR)
                                     (1) =    2850.
```

RELOCATION (CONTINUED)

```
DATA TO BE USED WITHIN THE AREA UP TO A RADIUS RA(IREMP)
( = OPTION 4):

UCLOI4(NS,NES)    (M.U./CAP-YR)
   (1, 2) =   97600.
   (1, 3) =  180800.
   (1, 4) =  122400.
   (1, 5) =   77600.
   ETC., SEE DATA IN CHAPTER 3.1

                                  UCCAP4(NS,K,NES)  (M.U./CAP)
                                  (K=1:NON-RESIDENT., K=2:HOUSING)
                                     (1,1, 1) =       0.
                                     (1,2, 1) =   54700.
                                     (1,1, 2) =  240400.
                                     (1,2, 2) =  359300.
                                     (1,1, 3) =  283500.
                                     (1,2, 3) =  614300.
                                     (1,1, 4) =  136100.
                                     (1,2, 4) =   58400.
                                     ETC., SEE DATA IN CHAPTER 3.1

                                  UCCAP1(NS,3)  (M.U./CAP)
                                  (K=3: CONSUMER DURABLES)
                                     (1) =   18000.

                                  UCLAN1(NS) (LAND)  (M.U./M**2)
                                     (1) =    24.00

 DATA TO BE USED OUTSIDE THE AREA OF A RADIUS RA(IREMP)
 ( = OPTION 1):

 UCLOI1(NS)  (M.U./CAP-YR)
    (1) =   35200.

                                  UCCAP1(NS,K)  (M.U./CAP)
                                  (K=1: NON-RESIDENT.,K=2:HOUSING,
                                   K=3: CONSUMER DURABLES)
                                     (1,1) =   20300.
                                     (1,2) =   93200.
                                     (1,3) =   18000.

                                  UCLAN1(NS) (LAND)  (M.U./M**2)
                                     (1) =    24.00
```

```
RELOCATION (CONTINUED)
GENERAL INPUT VALUES:

   SHARE OF PEOPLE USING PRIVATE TRANSPORT MEANS,  SPRRL =  0.80 (-)
   RECOVERY TIME,  TRESEC(NES) (YR)
                              ( 1) =  2.00
                              ( 2) =  3.00
                              ( 3) =  6.00
                              ETC., SEE DATA IN CHAPTER 3.1

   RECOVERY TIME,  TREC   =  2.00 (YR)
   INTEREST RATE,  RINTRL =  7.00 (%/YR)
   DISCOUNT RATE,  DISRL  =  5.00 (%/YR)
   DEPRECIATION RATE LOST CAPITAL SERVICES,  DEPRCA(K) = 16.00 /  2.00 / 16.00 (%/YR),  DEPRLA =  0.00 (%/YR)


DECONTAMINATION
***************

FACTOR TO ADJUST UNIT COSTS: FUCDC =  1.0000

OPTION TO BE USED FOR COST CALCULATIONS:  OPTION 1  -  AREA-BASED CALCULATION

NOTE: THE RESTRICTIONS IMPOSED BY THE PARAMETERS "IEMP" AND "IREMP" FOR THE CALCULATION OF RELOCATION COSTS
ACCORDING TO OPTION 4 ARE ALSO VALID FOR THE CACLULATION OF DECONTAMINATION COSTS

UNIT COSTS (ADJUSTED):
   AREA-BASED VALUES,    UDECA(N)  (M.U./M**2)

                    (1)       (2)       (3)       (4)       (5)       (6)       (7)       (8)
      UDECA(N)     8.60      8.60      8.60      8.60      8.60      8.60      8.60      8.60

                    (9)       (10)      (11)      (12)      (13)      (14)      (15)
      UDECA(N)     8.60      8.60      8.60      8.60

GENERAL INPUT VALUES:

   DISCOUNT RATE,  DISDC =  5.00 (%/YR)

   AS A REMINDER: DECONTAMINATION FACTOR,  DFMAX(N) (-)

                (1)  (2)  (3)  (4)  (5)  (6)  (7)  (8)  (9)  (10) (11) (12) (13) (14) (15)
      DFMAX(N)  1.0  1.0  1.0  3.0  3.0  3.0  3.0  3.0  3.0  3.0  3.0  3.0

*****  END OF INPUT WITHOUT ERROR  *****
```

5. Appendix: Input-Output Procedures of Additional Statistical Data Files

In Chapter 3.3, the procedure of processing additional statistical data has been described in general terms. The different levels of data information in this process are:

1) Original input data
2) Input data for the GRIDS preprocessing program
3) Input data for the ECONOMICS module in COSYMA.

These levels will be discussed in more detail in the following sections.

5.1 Original Input Data

The following original input information has been made available for use in option 4 of evacuation / relocation costs (the origin of these data is beyond the scope of this report and will not be described here.

1) Statistical data on the **number of employees in different economic sectors** of each municipality in the Federal Republic of Germany; these sectors are entered in the list of Table 3.1 on p. 13 (data are stored in **$STAT.DATA**).

2) Data on the **centre** of 7561 administrative units (municipalities and so-called "local areas" - see below) in geographic projection (longitude and latitude) (data are stored in **LAND99.DATA**).

3) Data on the **border** (polygons) of each of the 8583 municipalities in Lambert coordinates (data are stored in **LANDxx.DATA**, with xx being the code numbers of the federal states - for details see list on p. 37).

4) Data on the **settlement area** of each grid element in a 500 m x 500 m grid for selected nuclear sites in Germany up to a distance of 25 km (data are stored in **STDNRyy.BESIED**, with yy being the code number of the nuclear sites; for details see Table 5.1 on p. 32). Up to now, only two data files of selected nuclear sites have been made available as an example.

Notes:
As already explained in Chapter 3.3, the statistical data mentioned in 1) have been taken from the National Census made in Germany in 1987 - this means that only data of the "old" federal states are available; the former German Democratic Republic still existed at that time, but no comparable data are available for that area.

Another restriction should be mentioned: There are 8583 municipalities in Germany of which 1131 belong to the federal state of Schleswig-Holstein. Data on the number of employees in the 18 economic sectors (9 main sectors + 9 subsectors of "2") listed in Table 3.1 are available for all municipalities in Germany except those in Schleswig-Holstein. In Schleswig-Holstein, for reasons of secrecy, data refering to municipalities exist only for the 10 main sectors, and information on the subsectors of "2" is available only for 109 so-called "local areas" whith each "local area" comprising several municipalities. On the whole, this means that the following data are available: data on 18 economic sectors in (8583 - 1131 + 109 =) 7561 administrative units; data on 10 economic sectors in 8583 administrative units.

Data of 4) have been taken from the Digital Feature Analysis Data (DFAD) /5/ and have been processed with a special preprocessing program.

5.2 *Input Data for the GRIDS Program - The 25 km² Grid for Germany*

As a first step, the grid itself is generated. Then, for each municipality the grid elements are determined that are covered by the area of this municipality - this is done with the help of the centre coordinates. Next, the respective data of this municipality (population + number of employees) are distributed among the grid elements according to the fractions of the grid elements on the total area of the municipality. As one grid element may belong to more than one municipality, the data in each grid element are finally summed up.

5.2.1 Determination of the Grid

In x-direction (longitude):

$$XRAST(J) = RLMIN + (J-1) \times DELRL \qquad J = 1 \text{ to } 107$$

with RLMIN = 5.85
DELRL = 0.075

In y-direction (latitude):

YRAST(1) = 47.26
YRAST(2) = 47.30
YRAST(3) = 47.34

YRAST(M) = BR100(MM) (primary elements of the EUROPEAN GRID)

with M = 4 MM = 1
M = 24 MM = 2
M = 44 MM = 3

M = 64	MM = 4
M = 84	MM = 5
M = 104	MM = 6
M = 124	MM = 7
M = 144	MM = 8
M = 164	MM = 9

YRAST(N) = YRAST(N-1) + DELBR(NN) (20-fold subdivision)

with	N = 5 to 23	NN = 1
	N = 25 to 43	NN = 2
	N = 45 to 63	NN = 3
	N = 65 to 83	NN = 4
	N = 85 to 103	NN = 5
	N = 105 to 123	NN = 6
	N = 125 to 143	NN = 7
	N = 145 to 163	NN = 8
	N = 165 to 183	NN = 9

BR100(1 to 10) = {47.38, 48.18, 49.00, 49.83, 50.68, 51.53, 52.4 1, 53.30, 54.22, 55.15}

DELBR(NN) = (BR100(NN + 1) - BR100(NN)) / 20 with NN = 1 to 9.

5.2.2 Distribution of Municipalities among the Grid Elements

The location of each municipality within the grid is given by the centre coordinates. For each municipality, first the central grid element is determined. Dependent on the total area, the municipality is then distributed over one (central) or more (neighboring) grid elements according to the following procedure:

5.2.2.1 Distribution of the Area of Each Municipality on the Grid Elements

Up to F = 30 km²:
Total fraction in the central grid element.

F = 30 up to 125 km²:
Fraction 25/F in the central grid element, the balance in equal parts in 4 neighboring grid elements.

F = 125 up to 150 km²:
In equal parts in the central and 4 neighboring grid elements.

F = 150 up to 225 km²:
Fraction 25/F in the central grid element, the balance in equal parts into 8 neighboring grid elements.

F = 225 up to 270 km²:
In equal parts in the central and 8 neighboring grid elements.

F = 270 up to 625 km²:
Fraction 225/F in the central and 8 immediately neighboring grid elements, the balance in equal parts in 16 following neighboring grid elements.

F > 625 km²:
In equal parts in the central and 24 neighboring grid elements.

5.2.2.2 *Calculation of Statistical Data in Each Grid Element*

In each grid element (J,I) the statistical data EMPL (population + number of employees in 18 economic sectors according to Table 3.1 on p. 13) are determined by multiplication of the values EMP of each municipality by the respective area fractions GEMANT that have been calculated before, and by summing up the data of different municipalities in the same grid element:

$$EMPL_{K,J,I} = \sum_{KENN=1}^{IANZ} EMP_{K,KENN} \cdot GEMANT_{KENN,J,I}$$

with

$EMPL_{K,J,I}$ = population + number of employees of economic sector K in grid element (J,I),

$EMP_{K,KENN}$ = population + number of employees of economic sector K in municipality KENN,

$GEMANT_{KENN,J,I}$ = fraction of area of municipality KENN in grid element (J,I)

J = index of grid elements in x-direction, J = 1 to 107,

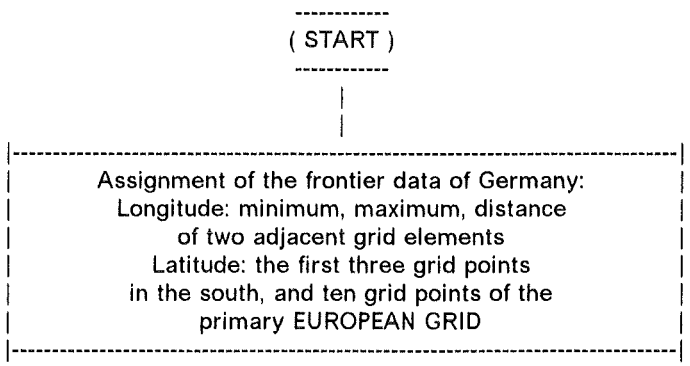
I = index of grid elements in y-direction, I = 1 to 183,

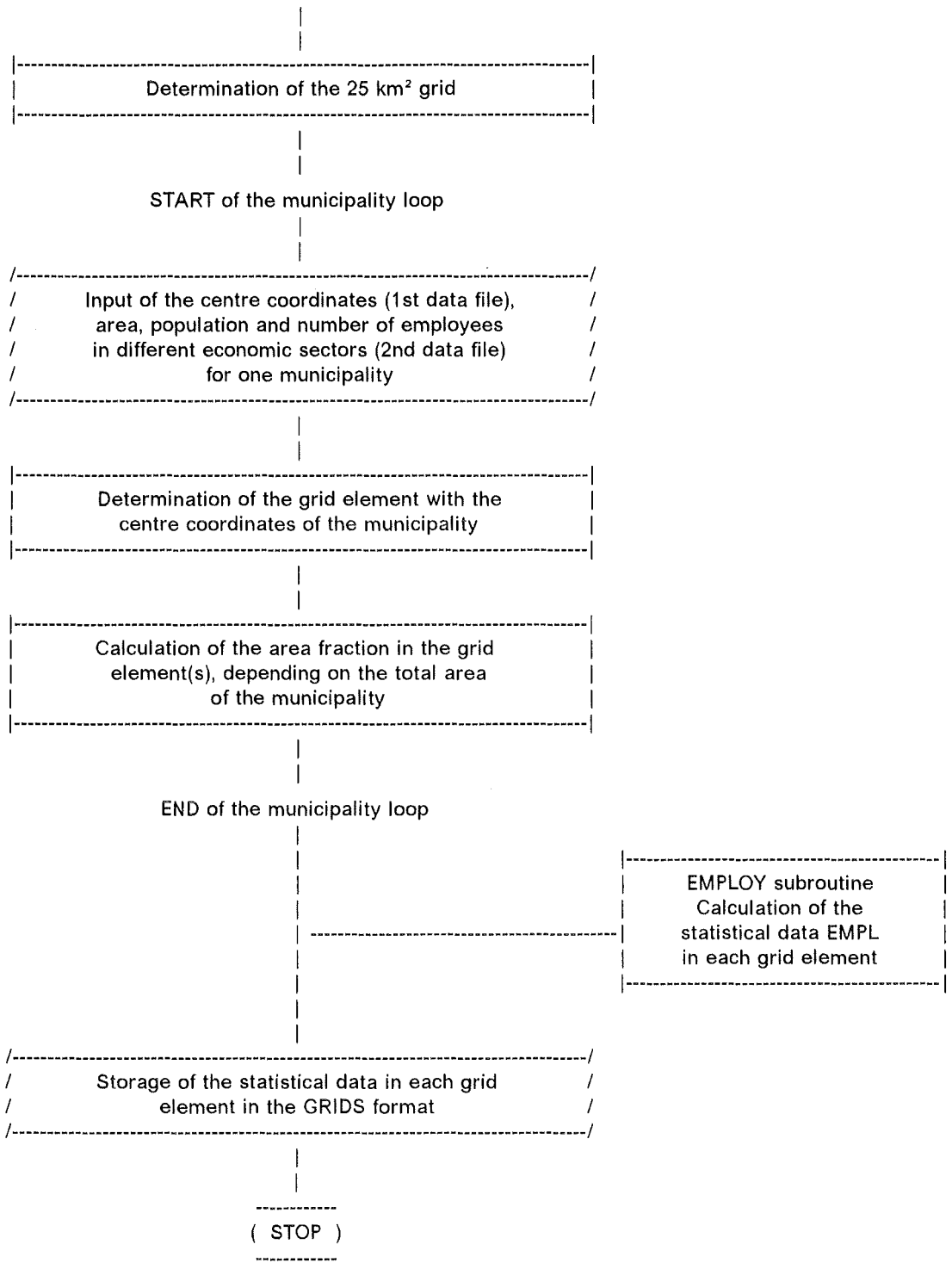
K = index of economic sector, K = 1 to 19,

IANZ = number of municipalities in each grid element (J,I).

5.2.3 Program Description

5.2.3.1 *Flow Chart*





5.2.3.2 *Input Description*

IUNIT1 = 1: Input of centre coordinates for each municipality

Data set: **LAND99.DATA**

(RECFM = FB, LRECL = 80, BLKSIZE = 8000)

Data to be read in for each municipality:

IW1 = code number of the municipality
XZENT = longitude of centre
YZENT = latitude of centre

FORMAT(I20,10X,2F10.2)

IUNIT2=20: Input of area, population and number of employees in different economic sectors for each municipality. Data are read in as INTEGER*4 and changed into REAL*4.

Data set: **$STAT.DATA(BRD5X5)**
(RECFM=FB, LRECL=200, BLKSIZE=27800)

Data to be read in for each municipality:

1st record:

NIGEM	=	code number of the municipality
CIGEM(5)	=	name of the municipality
IFL	=	area (ar)
IBEV	=	population
IHAUS	=	number of private households (not used)
IWOH	=	number of dwellings (not used)
ISUMBE	=	total of all employees (not used)
ILANDW	=	number of employees sector "0" - see Table 3.1 on p. 13
IENERG	=	- sector "1"
IVERAR	=	- sector "2" (not used)
IBAU	=	- sector "3"
IHAND	=	- sector "4"
IVERK	=	- sector "5"
IKRED	=	- sector "6"
IDIEN	=	- sector "7"
IORG	=	- sector "8"
IGEBK	=	- sector "9"

FORMAT(I10,5A4,10X,4I10,10X,11I10)

2nd record:

IFL1 to IFL8	=	different specific areas (not used)
ICHEM	=	number of employees sector "20" - see Table 3.1 on p. 13
IKUNST	=	- sector "21"
ISTEIN	=	- sector "22"
IMET	=	- sector "23"
IMASCH	=	- sector "24"
IELEK	=	- sector "25"
IHOLZ	=	- sector "26"
ILEDER	=	- sector "27"
INAHR	=	- sector "28"

FORMAT(20x,8I10,10x,9I10)

The procedure for reading the input is:

```
      INTEGER*4 IW1
      INTEGER*4 IFL,IBEV,IHAUS,IWOH,ISUMBE,
     *     ILANDW,IENERG,IVERAR,IBAU,IHAND,IVERK,IKRED,IDIEN,IORG,IGEBK,
     *     IFL1,IFL2,IFL3,IFL4,IFL5,IFL6,IFL7,IFL8,
     *     ICHEM,IKUNST,ISTEIN,IMET,IMASCH,IELEK,IHOLZ,ILEDER,INAHR
      REAL*4 XZENT,YZENT
      CHARACTER*4 NAMST(5),CIGEM(5)

      IGEM=0
      IUNIT1=1
      REWIND IUNIT1
      IUNIT2=20
      REWIND IUNIT2
  140 READ(IUNIT1,801,END=161) IW1,XZENT,YZENT
      IGEM=IGEM+1
      READ(IUNIT2,520) NIGEM,CIGEM,IFL,IBEV,IHAUS,IWOH,ISUMBE,
     *     ILANDW,IENERG,IVERAR,IBAU,IHAND,IVERK,IKRED,IDIEN,IORG,IGEBK,
     *     IFL1,IFL2,IFL3,IFL4,IFL5,IFL6,IFL7,IFL8,
     *     ICHEM,IKUNST,ISTEIN,IMET,IMASCH,IELEK,IHOLZ,ILEDER,INAHR
           :
           :
           :
      GO TO 140
  161 CONTINUE
           :
           :
           :
  520 FORMAT(I10,5A4,10X,4I10,10X,11I10/20X,8I10,10X,9I10)
  801 FORMAT(I20,10X,2F10.2)
```

5.2.3.3 Output Description

IUNIT3 = 71,72,.....,89: Storage of statistical data EMPL as REAL*8 data EMPL8 in the format to be used in GRIDS. For each economic sector zz a separate data set is produced.

Data set: **BRD25QKM.zz**
(RECFM = VBS, LRECL = 6000, BLKSIZE = 6000)

with	zz = POPUL	=	population	
	zz = AGRICUL	=	number of employees	sector "0"
	zz = ENERGY	=	- -	sector "1"
	zz = CHEMIST	=	- -	sector "20"
	zz = PLASTIC	=	- -	sector "21"
	zz = MINING	=	- -	sector "22"
	zz = METAL	=	- -	sector "23"
	zz = STEEL	=	- -	sector "24"
	zz = ELECTR	=	- -	sector "25"
	zz = WOOD	=	- -	sector "26"
	zz = LEATHER	=	- -	sector "27"
	zz = FOOD	=	- -	sector "28"
	zz = CONSTR	=	- -	sector "3"
	zz = COMMERCE	=	- -	sector "4"
	zz = TRANSP	=	- -	sector "5"

zz = BANKING	=	-	-	sector "6"
zz = SERVICES	=	-	-	sector "7"
zz = NONPROFO	=	-	-	sector "8"
zz = AUTHORIT	=	-	-	sector "9"

Data are stored unformatted for the row of grid elements of each latitude from west to east and from south to north:

YRAST = latitude of the following grid elements
ILMINE = index of longitude of the most western grid element
ILMAXE = index of longitude of the most eastern grid element
EMPL8 = statistical data for all grid elements with latitude YRAST and longitudes from ILMINE to ILMAXE-ILMINE+1 (=107 values)

The procedure for storing the output data is:

```
      INTEGER*4 IBMAX,ILMAX,ILMINE,ILMAXE
      REAL*4 YRAST(200),EMPL(19,150,200)
      REAL*8 EMPL8(150)

      IBMAX=183
      ILMAX=107
      DO 195 K=1,19
      WRITE(6,612) K
      IUNIT3=70+K
      DO 190 I=1,IBMAX
      DO 192 J=1,ILMAX
      EMPL8(J)=DBLE(EMPL(K,J,I))
  192 CONTINUE
      ILMINE=78
      ILMAXE=184
      IF((I.LT.10).OR.(I.GT.100))
     *WRITE(6,*) YRAST(I),ILMINE,ILMAXE,(EMPL8(J),J=1,ILMAX)
      WRITE(IUNIT3) YRAST(I),ILMINE,ILMAXE,(EMPL8(J),J=1,ILMAX)
  190 CONTINUE
  195 CONTINUE
  612 FORMAT(1H1,' ECONOMIC SECTOR: ',I2//)
```

5.3 *Input Data for the GRIDS Program - The 500 m x 500 m Grid for Selected Nuclear Sites*

For the near range of a nuclear site to be considered a quadratic grid with grid elements of 500 m x 500 m is generated up to a distance of about 25 km (i.e. 110 x 110 grid elements) with the site located in the centre of the grid. All municipalities that cover this grid are determined, and the area of each of these municipalities is distributed over the grid elements with the help of the INGEB subroutine which transfers the border coordinates of the municipality into the grid and determines all grid elements inside the polygon. In addition, the fraction of settlement on the area of each grid element is used and read in from a separate data file.

The statistical data (population + number of employees) are then distributed among all grid elements that belong to the municipality according to the fraction of the grid element on the area of the municipality and the fraction of the settlement on the area of the grid element. Finally, the data of different municipalities in the grid elements are summed up.

5.3.1 Determination of the Grid

In x- and y-directions (UTM-km):

XRAST(1) = XA
YRAST(1) = YA
XRAST(IRAST) = XRAST(IRAST-1) + 0.5
YRAST(IRAST) = YRAST(IRAST-1) + 0.5

with IRAST = 2 to 110
XA = INTEGER(XSTU) / 5 × 5 - 25. - 0.25
YA = INTEGER(YSTU) / 5 × 5 - 25. - 0.25

XSTU,YSTU = coordinates of the site in UTM projection

Note:
The border coordinates of each municipality are given in a Cartesian system of coordinates that is called IWK projection. This IWK projection is to a very large extent - but not in absolute terms - identical with the Lambert system of coordinates in Zone 3. With the TRANSA subroutine the IWK/Lambert projection may be transferred into UTM projection. Verifying the results has shown that deviations may occur up to 2 km. In order to compensate these deviations in the 500 m x 500 m grid, the border coordinates are adapted for each nuclear site with the correction factors given in Table 5.1.

5.3.2 Distribution of Municipalities on the Grid

5.3.2.1 Distribution of the Area of Each Municipality on the Grid Elements

For the grid of a nuclear site all municipalities are determined that cover this grid either completely or partially. In order to treat correctly municipalities that cover the grid only partially, the original size is extended during the process of calculation (and reduced afterwards) in such a way that all municipalities are completely covered by grid elements. The border coordinates of each of the determined municipalities are transferred from IWK/Lambert to UTM projection and adapted with the correction factors of Table 5.1.

The grid elements that belong to a municipality are determined with the help of the INGEB subroutine. As already mentioned, the fraction of settlement on the area of each grid element is used in addition.

Table 5.1: **Correction Factors of Nuclear Sites for Transfer from IWK to UTM**

Code Number	Name	Coordinates X / Y (UTM-km)	Correction Factor X / Y (UTM-km)
1	Brokdorf	522.90 / 5967.26	-1.17 / 0.40
2	Brunsbüttel	513.25 / 5971.74	-1.68 / 0.54
3	Esenshamm	465.26 / 5920.18	-1.62 / -0.46
4	Hamm-Schmeh.	429.03 / 5726.16	(not calculated)
5	Krümmel	594.27 / 5918.73	-1.42 / 0.04
6	Stade	535.19 / 5941.60	-0.96 / 0.22
7	Vahnum	325.16 / 5731.52	(not calculated)
8	Biblis A	457.94 / 5506.69	-1. / -0.30
9	Neupotz	451.92 / 5438.30	(not calculated)
10	Philippsburg	459.41 / 5455.94	-0.62 / 0.16
11	Wyhl	399.04 / 5338.47	-0.63 / 1.30
12	Grafenrheinfeld	584.96 / 5537.62	-0.68 / 0.14
13	Gundremmingen	603.65 / 5374.38	-0.85 / 0.78
14	Isar-Ohu	743.20 / 5389.05	-0.97 / 1.35
15	Borken	521.74 / 5657.68	(not calculated)
16	Grohnde	528.24 / 5765.22	-1.42 / -0.10
17	Mühlheim-Kärlich	392.54 / 5585.42	-1.48 / -0.72
18	Neckarwestheim	512.65 / 5432.36	-0.91 / 0.57
19	Würgassen	527.12 / 5721.16	-1.08 / -0.53
20	Emsland	386.03 / 5815.10	-0.61 / 0.62
21	Pfaffenhofen	626.80 / 5387.98	(not calculated)
22	Obrigheim	505.62 / 5468.24	-1.06 / 0.30
23	Kalkar	315.50 / 5738.48	(not calculated)
24	ALKEM-Hanau	498.28 / 5552.62	(not calculated)
25	EXXON-Lingen	386.75 / 5816.04	(not calculated)
26	Gronau	368.73 / 5787.09	(not calculated)
27	Dragahn	631.48 / 5883.46	(not calculated)
28	Wackersdorf	735.06 / 5468.19	(not calculated)

5.3.2.2 *Calculation of Statistical Data in Each Grid Element*

In each grid element the statistical data EMPL (population + number of employees in 18 economic sectors according to Table 3.1 on p.13) are determined by multiplication of the values EMP of each municipality by the respective fractions of settlement area BESANT, and by summing up the data of different municipalities in the same grid element:

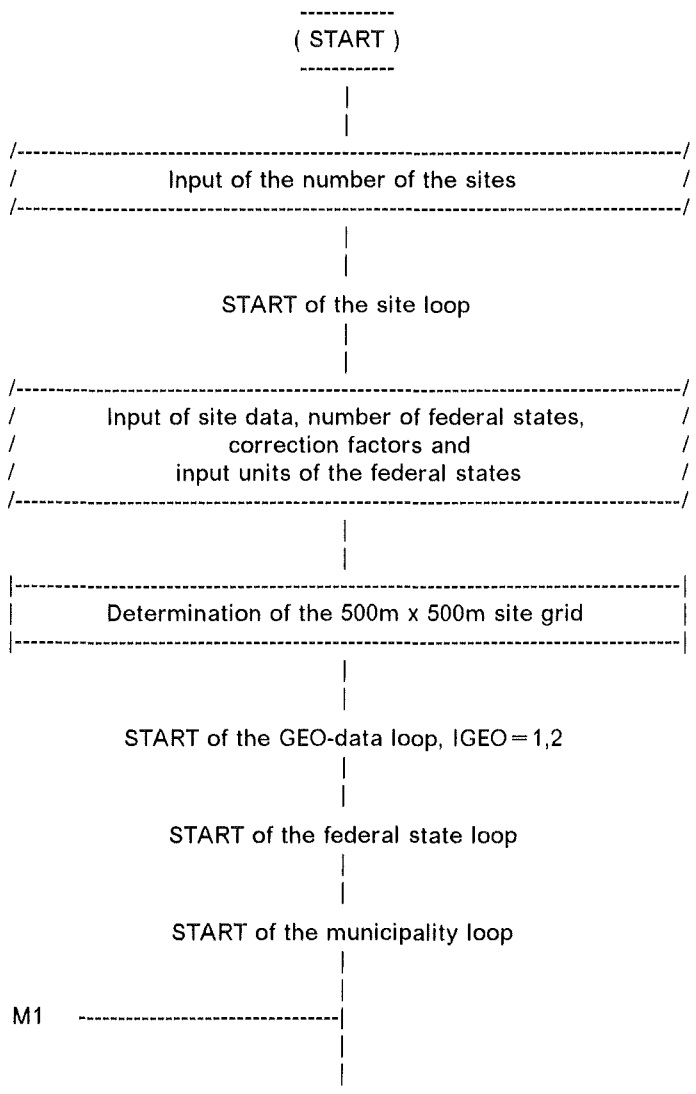
$$EMPL_{K,J,I} = \sum_{KENN=1}^{IANZ} EMP_{K,KENN} \cdot BESANT_{KENN,J,I}$$

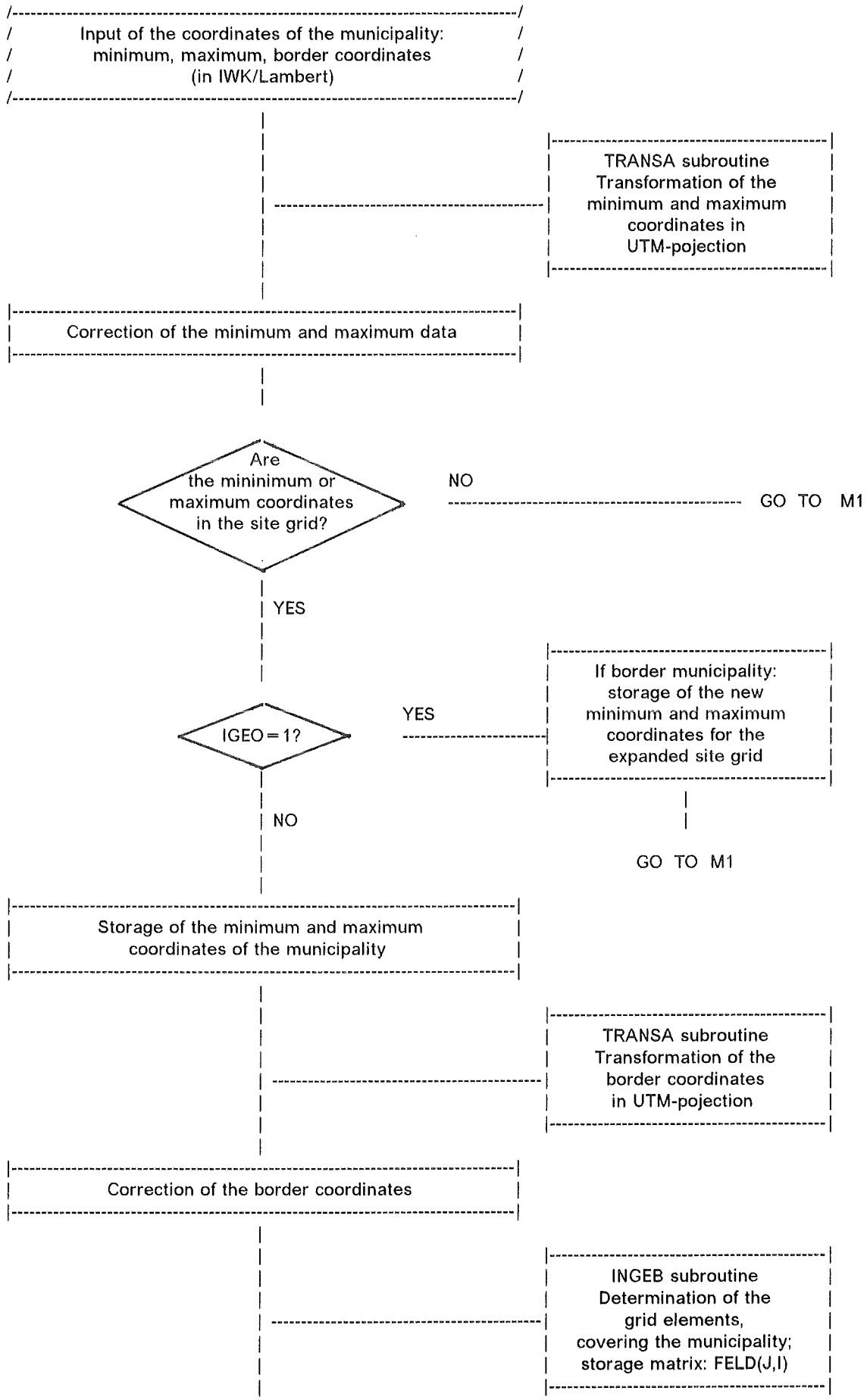
with

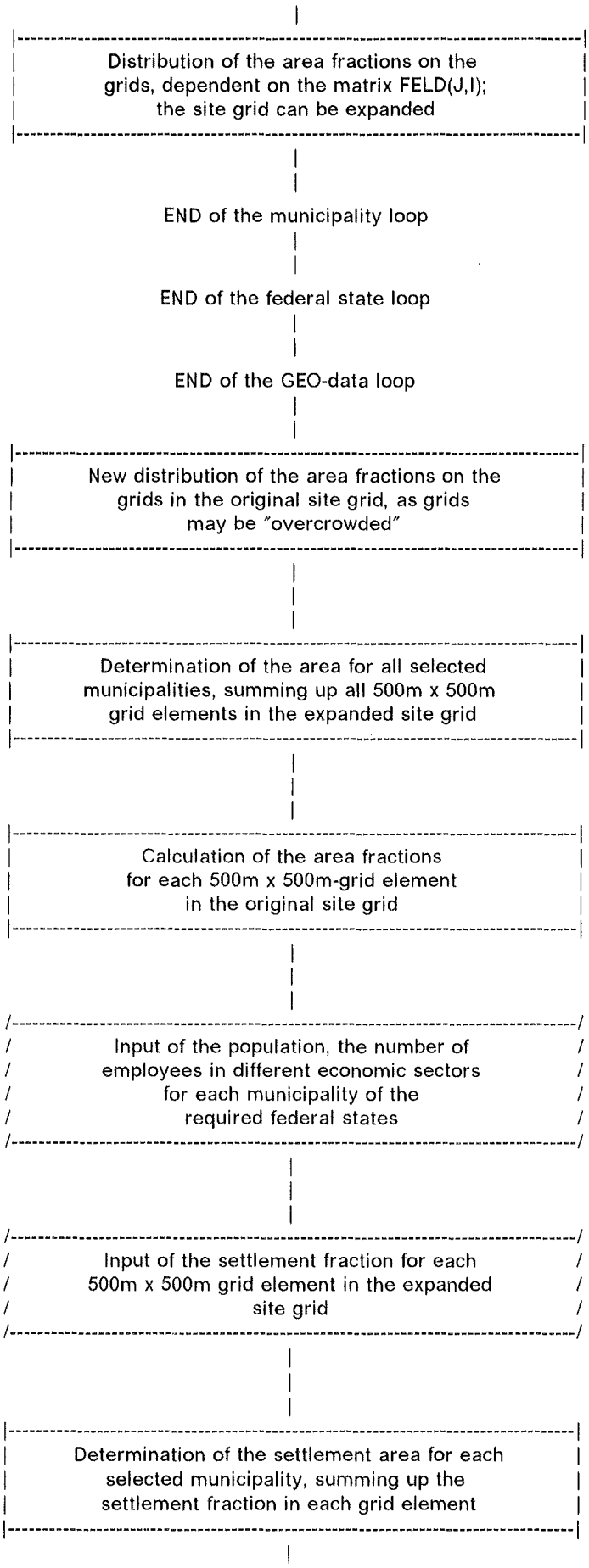
$EMPL_{K,J,I}$	=	population + number of employees of economic sector K in grid element (J,I)
$EMP_{K,KENN}$	=	population + number of employees of economic sector K in municipality KENN
$BESANT_{KENN,J,I}$	=	fraction of settlement area of municipality KENN in grid element (J,I)
J	=	index of grid elements in x-direction, J = 1 to 110
I	=	index of grid elements in y-direction, I = 1 to 110
K	=	index of economic sector, K = 1 to 19
IANZ	=	number of municipalities in each grid element (J,I)

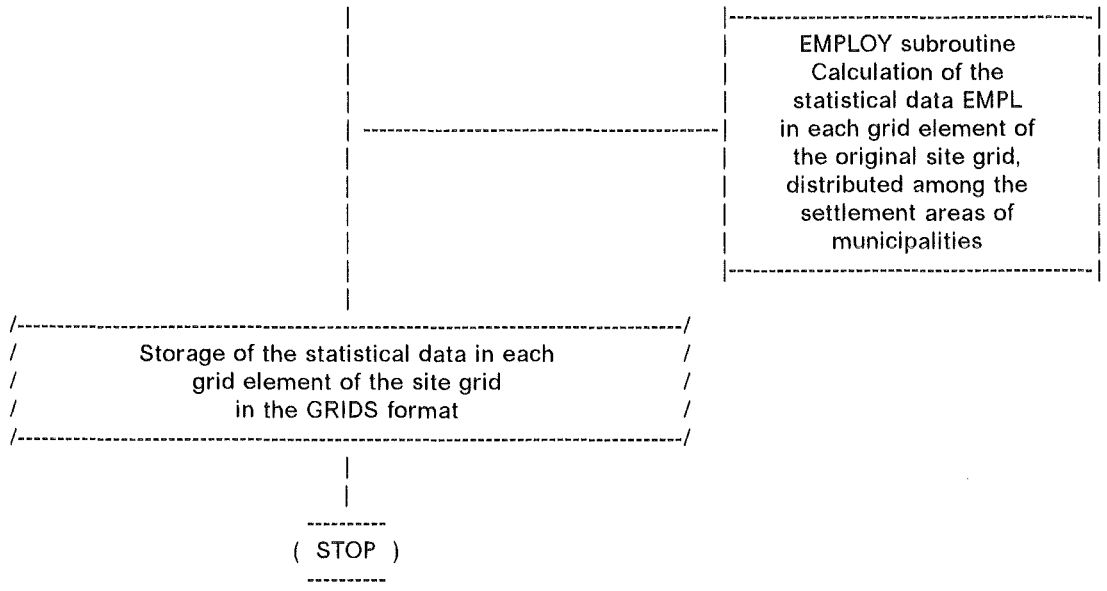
5.3.3 Program Description

5.3.3.1 Flow Chart




Input of the coordinates of the municipality: minimum, maximum, border coordinates (in IWK/Lambert)
TRANSA subroutine Transformation of the minimum and maximum coordinates in UTM-pojection
Correction of the minimum and maximum data
Are the mininimum or maximum coordinates in the site grid?
NO
GO TO M1
YES
IGEO=1?
YES
If border municipality: storage of the new minimum and maximum coordinates for the expanded site grid
GO TO M1
NO
Storage of the minimum and maximum coordinates of the municipality
TRANSA subroutine Transformation of the border coordinates in UTM-pojection
Correction of the border coordinates
INGEB subroutine Determination of the grid elements, covering the municipality; storage matrix: FELD(J,I)


Distribution of the area fractions on the grids, dependent on the matrix FELD(J,I); the site grid can be expanded
END of the municipality loop
END of the federal state loop
END of the GEO-data loop
New distribution of the area fractions on the grids in the original site grid, as grids may be "overcrowded"
Determination of the area for all selected municipalities, summing up all 500m x 500m grid elements in the expanded site grid
Calculation of the area fractions for each 500m x 500m-grid element in the original site grid
Input of the population, the number of employees in different economic sectors for each municipality of the required federal states
Input of the settlement fraction for each 500m x 500m grid element in the expanded site grid
Determination of the settlement area for each selected municipality, summing up the settlement fraction in each grid element



5.3.3.2 *Input Description*

UNIT = 5: Input of nuclear sites

1st record:

ISTAND = number of nuclear sites

FORMAT(I2)

Data to be read in for each nuclear site:

2nd record:

NRST = code number of site
NAMST(5) = name of site
XSTU,YSTU = x /y-coordinates in UTM-km
IZ = code number of UTM zone
IBUND = number of federal states that cover the grid

FORMAT(I2,5A4,2F10.2,2I5)

3rd record:

XDEL = correction factor of x values
YDEL = correction factor of y values

FORMAT(2F10.2)

4th record:

LANDXX(1 to IBUND) = units to read data of different federal states

FORMAT(10I5)

IUNIT1 = LANDXX(1) to LANDXX(IBUND) : IWK/Lambert coordinates of municipalities

For each federal state that covers the grid:

Data set: **LANDxx.DATA**

(RECFM = FB, LRECL = 80, BLKSIZE = 8000)

with
- xx = 01: Schleswig-Holstein
- xx = 02: Hamburg, Bremen, Berlin
- xx = 03: Niedersachsen
- xx = 04: (not used)
- xx = 05: Nordrhein-Westfalen
- xx = 06: Hessen
- xx = 07: Rheinland-Pfalz
- xx = 08: Baden-Württemberg
- xx = 09: Bayern
- xx = 10: Saarland

Data to be read in for each municipality:

1st record:

IW1	= code number of municipality
XZENT	= x-coordinate of centre
YZENT	= y-coordinate of centre
XMIN	= x-coordinate of minimum
YMIN	= y-coordinate of minimum
XMAX	= x-coordinate of maximum
YMAX	= y-coordinate of maximum
IW2	= number of partial polygons (used only for read-in-procedure)
IW3	= total number of x/y coordinates

FORMAT(I10,6F10.2,I2,I4)

2nd record:

IW4(1 to IW2) = (not used)

FORMAT(20I4)

3rd record and following:

X(1 to IW3) = x-coordinates

Y(1 to IW3 + 1) = y-coordinates

FORMAT(8F10.0)

IUNIT2 = 10 + LANDXX(1) to 10 + LANDXX(IBUND): Input of area, population and number of employees in different economic sectors for each municipality. Data are read in as INTEGER*4 and changed into REAL*4.

Data set **$STAT.DATA(LANDxx)**

(RECFM = FB, LRECL = 200, BLKSIZE = 27800)

with xx: see list above

Data to be read in for each municipality:

1st record:

NIGEM	=	code number of municipality
CIGEM(5)	=	name of municipality
IFL	=	area [ar]
IBEV	=	population
IHAUS	=	number of private households (not used)
IWOH	=	number of dwellings (not used)
ISUMBE	=	total of all employees (not used)
ILANDW	=	number of employees sector "0" - see Table 3.1 on p. 13
IENERG	=	- - sector "1"
IVERAR	=	- - sector "2" (not used)
IBAU	=	- - sector "3"
IHAND	=	- - sector "4"
IVERK	=	- - sector "5"
IKRED	=	- - sector "6"
IDIEN	=	- - sector "7"
IORG	=	- - sector "8"
IGEBK	=	- - sector "9"

FORMAT(I10,5A4,10X,4I10,10x,11I10)

2nd record:

IFL1 to IFL8	=	different specific areas (not used)
ICHEM	=	number of employees sector "20" - see Table 3.1 on p. 13
IKUNST	=	- - sector "21"
ISTEIN	=	- - sector "22"
IMET	=	- - sector "23"
IMASCH	=	- - sector "24"
IELEK	=	- - sector "25"
IHOLZ	=	- - sector "26"
ILEDER	=	- - sector "27"
INAHR	=	- - sector "28"

FORMAT(20x,8I10,10x,9I10)

IUNIT4=60+1 to 60+ISTAND: Input of fraction of settlement area of each grid element of the extended grid:

Data set: **STDNRyy.BESIED**

(RECF=FB, LRECL=80, BLKSIZE=6000)

with yy = code number of the site (see Table 5.1 on p. 32)

Data to be read in for each nuclear site:

1st - 4th records:

TEXT(1 to 4) = comments

FORMAT(A80)

For each grid element from southwest to northeast:

5th record and following:

IBESY	=	index of latitude - starting with index 0
JBESX	=	index of longitude - starting with index 0
IBESP(JBESX+1,IBESY+1)	=	fraction of settlement area in the grid element (%)

FORMAT(I3,2I4)

The procedure for reading the input is:

```
      CHARACTER*4 NAMST(5),CIGEM(5)
      CHARACTER*1 TEXT(4,80)
      INTEGER*4 IW4(40),LANDXX(10),IBESP(200,200)
      REAL*4 XZENT,YZENT,XMIN,YMIN,XMAX,YMAX,X(734),Y(734)
C
      READ(5,500) ISTAND
C  LOOP OF SITES
      DO 1000 NSTO=1,ISTAND
            :
   10 READ(5,500) NRST,NAMST,XSTU,YSTU,IZ,IBUND
      READ(5,505) XDEL,YDEL
      IF(IBUND.GT.10) THEN
      WRITE(6,609) IBUND
      STOP
      END IF
      READ(5,510) (LANDXX(IR),IR=1,IBUND)
            :
C  LOOP OF FEDERAL STATES FOR READING COORDINATES OF MUNICIPALITIES
      IGEM=0
      DO 160 ILAND=1,IBUND
      IUNIT1=LANDXX(ILAND)
      REWIND IUNIT1
  101 READ(IUNIT1,801,END=160) IW1,XZENT,YZENT,XMIN,YMIN,XMAX,YMAX,IW2,IW3
      IF(IW2.GT.40) THEN
      WRITE(6,611) IW1
      STOP
      END IF
      READ(IUNIT1,802) (IW4(N),N=1,IW2)
C  FOR THE Y VALUES IW3+1 DATA ARE READ IN, AS AN EMPTY RECORD FOLLOWS
C  IF THE LAST RECORD CONTAINS 8 VALUES
      IW3R=IW3+1
      IF(IW3R.GT.734) THEN
      WRITE(6,602) IW1,IW3
      STOP
      END IF
      READ(IUNIT1,803) (X(IR),IR=1,IW3),(Y(IR),IR=1,IW3R)
            :
      GO TO 101
            :
  160 CONTINUE
            :
C  LOOP OF FEDERAL STATES FOR READING STATISTICAL DATA OF MUNICIPALITIES
      IGEMNR=1
      DO 400 ILAND=1,IBUND
      IUNIT2=10+LANDXX(ILAND)
      REWIND IUNIT2
  250 READ(IUNIT2,520,END=350)
     *    NIGEM,CIGEM,IFL,IBEV,IHAUS,IWOH,ISUMBE,
     *    ILANDW,IENERG,IVERAR,IBAU,IHAND,IVERK,IKRED,IDIEN,IORG,IGEBK,
     *    IFL1,IFL2,IFL3,IFL4,IFL5,IFL6,IFL7,IFL8,
```

```
      *     ICHEM,IKUNST,ISTEIN,IMET,IMASCH,IELEK,IHOLZ,ILEDER,INAHR
                :
       IGEMNR=IGEMNR+1
                :
       GO TO 250
  350 CONTINUE
  400 CONTINUE
       IGEMNR=IGEMNR-1
                :
C  INPUT OF FRACTIONS OF SETTLEMENT AREA OF EACH GRID ELEMENT
       IUNIT4=60+NSTO
       REWIND IUNIT4
       DO 410 JT=1,4
  410 READ(IUNIT4,905) (TEXT(JT,IT),IT=1,80)
  412 READ(IUNIT4,910,END=415) IBESY,JBESX,IBESP(JBESX+1,IBESY+1)
       GO TO 412
  415 CONTINUE
                :
 1000 CONTINUE
C
  500 FORMAT(I2,5A4,2F10.2,2I5)
  505 FORMAT(2F10.2)
  510 FORMAT(10I5)
  520 FORMAT(I10,5A4,10X,4I10,10X,I10,10I10/20X,8I10,10X,9I10)
  602 FORMAT(1H ,'$$$   ERROR: STORAGE PLACE OF X-,Y-COORDINATES ',
     * 'IS EXCEEDED AT MUNICIPALITY: ',I10/
     * 1H ,'Number OF POLYGONS " IS ',I5)
  609 FORMAT(1h ,'$$$   ERROR: NUMBER OF FEDERAL STATES HAS TO BE < 10 !')
  611 FORMAT(1h ,'$$$   ERROR: NUMBER OF PARTIAL POLYGONS OF ',
     * 'MUNICIPALITY: ',I10,' IS > 40')
  801 FORMAT(I10,6F10.2,I2,I4)
  802 FORMAT(20I4)
  803 FORMAT(8F10.0)
  905 FORMAT(80A1)
  910 FORMAT(I3,2I4)
```

5.3.3.3 *Output Description*

IUNIT3 = 71 to 89: Storage of statistical data EMPL as INTEGER*4-data IEMPL in the GRIDS format. For each economic sector zz a separate data set is generated.

Data set: **D500X500.zz.BESIED**
(RECFM = FB,LRECL = 678,BLKSIZE = 6780)

with zz: see list on p. 29/30

Data to be stored for each nuclear site:

1st record:

NRST	=	number of site
NAMST(5)	=	name of site
IZ	=	number of UTM zone
XSTU	=	x-coordinate [UTM]
YSTU	=	y-coordinate [UTM]

FORMAT(I2,5A4,I6,2F7.2)

For the row of grid elements of each latitude from south to north:

2nd record - 111th record:

IYGM	=	0
IXGM	=	0
NEMPL	=	110: number of grid elements
IEMPL	=	statistical data for all grid elements of this latitude from west to east

FORMAT(113I6)

The procedure for storing the output data is:

```
      DO 1000 NSTO=1,ISTAND
            :
            :
      DO 195 K=1,19
         CALL EMPLOY(K,IGEM,IGEMNR,NXSTRA,NXSTRE,NYSTRA,NYSTRE)
         WRITE(6,612) K
C
C     PRINTOUT AND STORAGE OF DATA OF ECONOMIC SECTORS IN THE GRID FORMAT
C
         IUNIT3=70+K
         WRITE(6,615) NRST,NAMST,IZ,XSTU,YSTU
         WRITE(IUNIT3,715) NRST,NAMST,IZ,XSTU,YSTU
         DO 190 I=NYSTRA,NYSTRE
            DO 192 J=NXSTRA,NXSTRE
               IEMPL(J)=INT(EMPL(J,I)+0.5)
  192       CONTINUE
            NEMPL=110
            WRITE(6,635) IYGM,IXGM,NEMPL,(IEMPL(J),J=NXSTRA,NXSTRE)
            WRITE(IUNIT3,735) IYGM,IXGM,NEMPL,(IEMPL(J),J=NXSTRA,NXSTRE)
  190    CONTINUE
  195 CONTINUE
 1000 CONTINUE
C
  612  FORMAT(1H1,'ECONOMIC SECTOR: ',I2//)
  615  FORMAT(1H ,I2,5A4,I6,2F7.2)
  715  FORMAT(I2,5A4,I6,2F7.2)
  635  FORMAT(1X,3I6,11I6/(1X,11I6))
  735  FORMAT(3I6,110I6)
```

5.4 *Input Data for the ECONOMICS Module in COSYMA*

5.4.1 Input / Output of the GRIDS Preprocessing Program

The data files described in the output description of Sections 5.2.3.3 and 5.3.3.3 - for the 25 km^2 for Germany and for the 500 m x 500 m grids for selected nuclear sites - are at the same time the input to the GRIDS preprocessing program of the COSYMA program system. GRIDS transfers the information from the x/y-input grids into a polar grid form (r,ϕ-coordinates) that can be used immediately in COSYMA.

The input/output procedure of the GRIDS program is described in detail in the COSYMA USER GUIDE /3, Chapter VI./ and is, therefore, not repeated here. The transfer procedure

in GRIDS has to be done separately for each of the 18 economic sectors and the population listed in Table 3.1 on p. 13. This leads to the following total output of GRIDS:

For each economic sector zz:

Data set: **KFKGRD.zz**
(RECFM = VBS,LRECL = 32760,BLKSIZE = 23440)

with zz: see list on p. 29/30

5.4.2 Input / Output of the EMPLOYEE Preprocessing Program

The EMPLOYEE preprocessing program has been generated additionally as an intermediate step between GRIDS and the ECONOMICS module in COSYMA with the aim to combine the information of all single data sets into one new data set, and, at the same time, give the user the possibility of combining economic sectors according to his own preference.

5.4.2.1 Input Description

LEMPIN(IEMIN) = 50+1 to 50+NEMIN: Input of the number of employees in different economic sectors; IEMIN = 1 to NEMIN (with NEMIN = 19):

For each economic sector zz:

Data set: **KFKGRD.zz** - see Section 5.4.1 above
(RECFM = VBS,LRECL = 32760,BLKSIZE = 23440)

Data to be read in for each nuclear site NS:

1st record:

ISCODE(NS	= code number of nuclear site
NRAD	= maximal number of radii
NSEC	= maximal number of radial sectors
RADII(IRAD = 1 to NRAD)	= radii
SITNAM(NS)	= name of nuclear site

2nd record and following: for each radial sector ISEC = 1 to NSEC:

EMPIN(ISEC,IRAD = 1 to NRAD,IEMIN)
= number of employees in each grid element (ISEC,IRAD) and economic sector IEMIN

The procedure of reading the input as well as that of combining different economic sectors will be described in Section 5.4.2.3.

5.4.2.2 *Output Description*

LEMPOUT = 90: Storage of the number of employees in different economic sectors

Data set: **KFKGRD.EMPL01**
(RECFM = VBS,LRECL = 32760,BLKSIZE = 23440)

Data to be stored:

1st record:

NEMOUT	=	number of economic sectors to be used for cost calculations
NSIT	=	number of nuclear sites
NRAD	=	number of radii
NSEC	=	number of radial sectors

for each nuclear site NS = 1 to NSIT:

2nd record:

EMPOUT(ISEC = 1 to NSEC,IRAD = 1 to NRAD,IEMOUT = 1 to NEMOUT)
= number of employees in each grid element (ISEC,IRAD) and each economic sector IEMOUT

The data EMPOUT stored in **KFKGRD.EMPL01** are finally read in by the ECONOMICS module of COSYMA with the parameter name ((((EMP(J,I,NES,NS),J = 1,JMAX),I = 1,IMAX),NES = 1,NESEC),NS = 1,NSTMAX) - see note in Chapter 3.1 on p. 10/11.

5.4.2.3 *Input / Output Procedure*

```
      PARAMETER(MAXSIT=5,MAXRAD=35,MAXSEC=72)
      PARAMETER(MAXEMP=20)
      CHARACTER*20 SITNAM(MAXSIT)
C
      DIMENSION  ISCODE(MAXSIT), LEMPIN(MAXEMP), RADII(MAXRAD)
      DIMENSION  EMPIN(MAXSEC,MAXRAD,MAXEMP)
      DIMENSION  EMPOUT(MAXSEC,MAXRAD,MAXEMP)
C
      DATA  LEMPIN /51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,
     1              66,67,68,69,70/
      DATA  LEMOUT /90/
      DATA  NSIT /2/,  NRAD /20/,  NSEC /72/
      DATA  NEMIN  /19/, NEMOUT /13/
C     NOTE: "NRAD" AND "NSEC" ARE COSYMA DEFAULT VALUES, "NSIT" AND "NEMOUT"
C     ARE EXAMPLE VALUES, "NEMIN = 19" IS DETERMINED BY GERMAN STATISTICAL DATA
                :
                :
C     READ & CHECK HEADER INPUT
      READ(LEMPIN(1)) ISCODE(1), MRAD, MSEC, (RADII(I),I=1,MRAD), SITNAM(1)
C     CHECK IF THE FOLLOWING PARAMETERS ARE EQUAL:
C        MRAD = NRAD
C        MSEC = NSEC
      WRITE(LEMOUT) NEMOUT,NSIT,NRAD,NSEC
      REWIND LEMPIN(1)
                :
```

```
                :
      DO 121 NS=1,NSIT
         DO 131 IEMIN=1,NEMIN
C     READ INPUT
            READ(LEMPIN(IEMIN),END=999)
     1         ISCODE(NS),NRAD,NSEC,(RADII(I),I=1,MRAD),SITNAM(NS)
            DO 141 ISEC=1,NSEC
               READ(LEMPIN(IEMIN),END=999)
     1             (EMPIN(ISEC,IRAD,IEMIN),IRAD=1,NRAD)
  141       CONTINUE
  131    CONTINUE
C
C     COMBINE DIFFERENT ECONOMIC SECTORS
         DO 151 IRAD=1,NRAD
            DO 152 ISEC=1,NSEC
               EMPOUT(ISEC,IRAD,1)  = EMPIN(ISEC,IRAD,1)
               EMPOUT(ISEC,IRAD,2)  = EMPIN(ISEC,IRAD,2)
               EMPOUT(ISEC,IRAD,3)  = EMPIN(ISEC,IRAD,3)
               EMPOUT(ISEC,IRAD,4)  = EMPIN(ISEC,IRAD,4)
               EMPOUT(ISEC,IRAD,5)  = EMPIN(ISEC,IRAD,5)
     1                              + EMPIN(ISEC,IRAD,6)
     2                              + EMPIN(ISEC,IRAD,10)
               EMPOUT(ISEC,IRAD,6)  = EMPIN(ISEC,IRAD,7)
     1                              + EMPIN(ISEC,IRAD,8)
     2                              + EMPIN(ISEC,IRAD,9)
               EMPOUT(ISEC,IRAD,7)  = EMPIN(ISEC,IRAD,11)
     1                              + EMPIN(ISEC,IRAD,12)
               EMPOUT(ISEC,IRAD,8)  = EMPIN(ISEC,IRAD,13)
               EMPOUT(ISEC,IRAD,9)  = EMPIN(ISEC,IRAD,14)
               EMPOUT(ISEC,IRAD,10) = EMPIN(ISEC,IRAD,15)
               EMPOUT(ISEC,IRAD,11) = EMPIN(ISEC,IRAD,16)
               EMPOUT(ISEC,IRAD,12) = EMPIN(ISEC,IRAD,17)
               EMPOUT(ISEC,IRAD,13) = EMPIN(ISEC,IRAD,18)
     1                              + EMPIN(ISEC,IRAD,19)
  152       CONTINUE
  151    CONTINUE
C
C     STORE OUTPUT
         WRITE(LEMOUT) ISCODE(NS),(((EMPOUT(ISEC,IRAD,IEMOUT),
     1                    ISEC=1,NSEC),IRAD=1,NRAD),IEMOUT=1,NEMOUT)
  121 CONTINUE
C
  999 CONTINUE
```

6. References

/1/ D. Faude:
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/2/ Federal Office of Statistics, Wiesbaden:
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/3/ I. Hasemann, A. Jones (comp.):
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