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Production system planning in Competence-cell-based Networks

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Autonomous, elementary units of production, co-operating in temporary networks, are considered as a key organisational form of enterprises in the 21st century. A scientific approach is provided by networks based on customer-oriented, directly linked, smallest autonomous business units called Competence Cells. Models for Competence Cells and their networking were developed. For such networks also an operationalised concept of organisation is needed. With the 'Holistic Integration Method' (HIM) an organisational manual is provided. The general architecture of the Holistic Integration Method consists of the levels 'Portal', 'Process Engine' and 'Methods and Tools'. The concept of Competence-cell-based Networks leads to new requirements for the planning of production systems of such networks. Therefore a framework called 'PlaNet – Planning Concept for Networks' has been developed. PlaNet, which is a component of HIM, provides the means that enable the Competence Cells to solve their planning problems. The framework includes methodical and default components for planning and design logistics structures and production plants. The suitable basis for PlaNet has been found with the Systems Engineering Methodology (SE). Thus the components of the methodical concept of PlaNet are derived from the components of SE. The Net Planning Assistant with its Production Database is a toolset which comprises software implementing the methods of PlaNet including tools for participative planning.

Keywords: production system planning; micro-enterprises, Competence-cell-based Networks; Holistic Integration Method, PlaNet; Net Planning Assistant

1 Introduction

There are currently two extreme cases emerging in global research about development of enterprises: On the one hand mergers and acquisitions lead to the development of large-scale enterprises, usually acting as 'Global Players', which concentrate in this way more and more capital. In the year 2000 approximately 30,000 such M&A activities with a volume of 3.5 trillion US dollar took place world-wide while in the year 2004 despite intensified world-economical basic conditions still more than 18,000 M&A activities with a volume of 1.5 trillion US dollar were arranged (KPMG 2004). The survey 'Inventing the organizations of the 21st Century' from Sloan School of Management at Massachusetts Institute of Technology (MIT) stated that globally acting large-scale enterprises steer ever larger financial streams, but increasingly lose direct control of the operational processes. Temporary networks of free individuals are increasingly filling this gap (Malone and Laubacher 1998). Therefore one scientific question arises: How large can enterprises grow while still remaining competitive?

The other extreme case is characterised by an increasing 'Atomisation' of existing and newly emerging enterprises, which concentrate in the shape of micro enterprises exclusively on their core competences. The 'classical enterprise' has been partly replaced by the type of the new independent self-employed (Wojda and Waldner 2000). The economical impact of small and medium-sized enterprises (SME) is undisputed. With

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their high share of gross value added they will also in the future be the backbone not only of the German economy as employers and innovators. For example in Germany the SME earn about 50 percent of the gross value added and employ two thirds of the workers (BMW 1998, IfM 2004, KfW 2004).

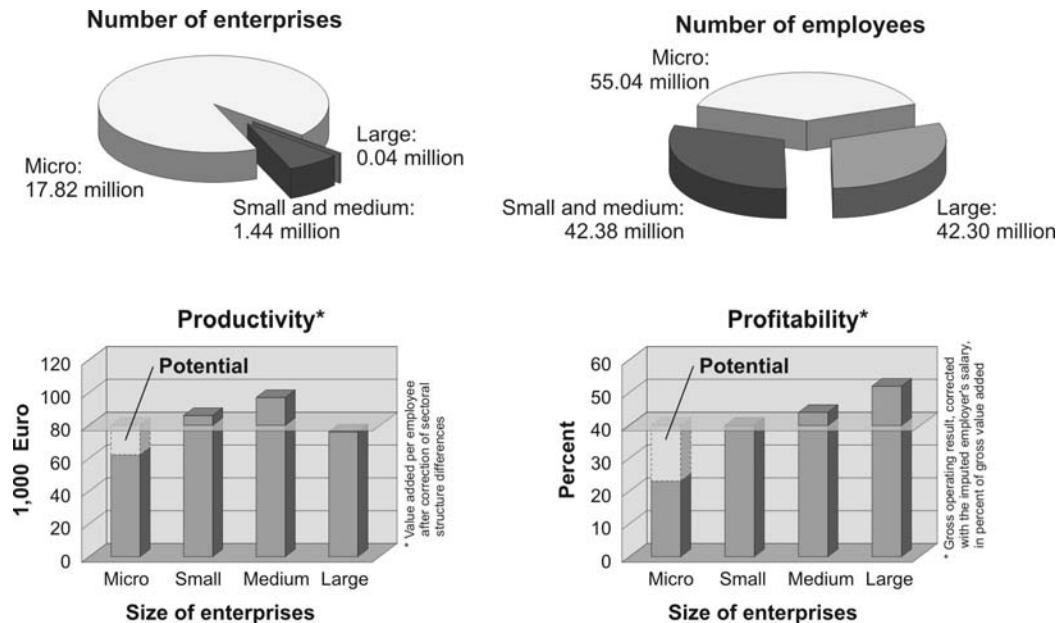


Figure 1. Economical impact und potential for improvement of micro-enterprises in Europe-19 (European Commission 2002a, European Commission 2004)

Furthermore since the start of the 21st century empirical proven tendencies can be observed that the economical impact of micro-enterprises will increase (figure 1) (European Commission 2002a, European Commission 2002b, European Commission 2004):

In the year 2003 there were 18 million micro-enterprises (with up to nine employees) in then Europe-19 (EU, Norway, Liechtenstein, Island and Switzerland), which provided work for more than 55 million people. Those are 92.3 % of European enterprises (share of SME: 99.8 %) and 39.4 % of all employees (share of SME: 69.7 %).

Because the productivity of these smallest-scale enterprises is below average (62 % compared to 76-97 % of small-, medium- and large-scale enterprises) and their profitability too (25 % compared to 40-52 % of small-, medium- and large-scale enterprises) they have the highest potential for improvement.

The growth of the number of employees is negatively correlated with the size of the enterprises. While the number of employees grows fastest in smallest-scale enterprises it grows most slowly in large-scale enterprises.

Smaller enterprises are less affected by the current situation of the economy than large enterprises. There is a positive correlation between the size of an enterprise and the negative effects on the turnover due to the economic situation. Smallest-scale enterprises therefore show in recessive economic situations a clearly more robust behaviour than medium- and large-scale enterprises. They show less willingness to release workers and are more determined to realise planned investments.

From 1988 to 2003 the number of smallest-scale enterprises has risen by six percent, while the number of small-, medium- and large-scale enterprises remained actually the same. In result the average business size has declined from eight employees in the year 1988 to seven in the year 2003 in Europe. Also in the new

1
2
3 member and candidate countries a clear decrease of the size of enterprises can be observed since the middle of
4 the 1990's.

5
6 Additionally the share of the SME in employment rose in the years from 1988 to 2003, while the percentage
7 of large enterprises declined. The current trend in Europe goes therefore generally towards a further increase
8 of the impact of small enterprises to the economy.

9 As a conclusion it can be said that the typical European enterprise is a micro-enterprise.

10 In this context the scientific question is: How small can performance units be while still remaining capable to
11 compete at the market independently? Regarding the current empirical investigations additionally another
12 question arises: How do smallest-scale enterprises have to act in order to optimally exploit the existing
13 potential, which is lying in an increase of the competitiveness compared to large-scale enterprises as well as in
14 the increase of the share of exports in their revenues? This research is meant to contribute to these questions.

15
16 Small enterprises have apart from their specific core competences only limited resources. Due to this they can
17 realise only sub-sequences of process chains. In order to acquire the ability for a holistic customer-oriented
18 provision of complex products respectively services, either missing competences must be obtained or be
19 supplemented by co-operation and cross-linking.

20
21 Present forms of co-operation are mainly based on hierarchical structures in and between enterprises. These
22 co-operations often are dominated by a single large-scale enterprise both from a technical-organisational and
23 an economical point of view. Dependencies are mandatory. The achieved advantage of relative stability
24 conflicts with the disadvantage of unilateral dominance. While these dependencies work as restrictions for
25 regionally established enterprises, they lead to significant market entrance barriers for small- and smallest-
26 scale enterprises as well as for start-ups. The result is that regional competences are not completely utilised
27 and besides an economically desirable dynamic in establishing and developing small enterprises is obstructed.
28 (Enderlein *et al.* 2003)

29
30 Large-scale enterprises accumulate more competences through M&A activities, they segment and cross-link
31 them strategically by hierarchical structures. In contrast a trend appears at SME and particularly at smallest-
32 scale enterprises for:

- 33 • 'elementarisation' and specialisation of competences,
- 34 • customer-oriented, order-dependent cross-linking.

35
36 This trend is caused by reasons of the small enterprises' function specifics, structure, resources and
37 commitment to their location.

38
39 Therefore it is necessary to aim future efforts more intensively at the organisation of non-hierarchical
40 production and organisational structures. This is supported by studies that consider autonomous, elementary
41 business units (Laubacher *et al.* 1997), co-operating in temporary networks (Malone and Laubacher 1998)
42 also called 'nanocorps' (Salmons and Babitsky 2001), as form of enterprise organisation of the future.

43
44 In a similar way the Delphi-survey (DELPHI'98 1998), a study commissioned by the German Department of
45 Education and Science (BMBF), points out temporary networks as the dominating organisational form for the
46 development and manufacturing of products in the production and service domain of the coming decades.

47 Clusters of SME have gained considerable importance in a number of other European countries besides
48 Germany such as Italy (UNIDO 2006) and France (Villarreal Lizárraga *et al.* 2005).

49 An urgent need to lay a scientific foundation to the so far rather empirical exploration of collaborative
50 networks has been identified (See Camarinha-Matos *et al.* 2005).

51 52 53 **2 Vision and concept**

54
55 Due to this development in manufacturing organisation, which in recent years has been lastingly influenced
56 by phenomena of 'elementarisation' and networking, a specific vision aimed at small and medium-sized
57
58
59
60

business (figure 2) has been developed at the Collaborative Research Centre (CRC) 457 'Non-hierarchical Regional Production Networks' (SFB457 1999):

Regionally, elementary business units – called Competence Cells – are co-operating in non-hierarchical production networks in a customer-oriented manner and thus meet global competition.

It is the long-term goal of the CRC 457 to investigate this vision scientifically. Theories and models are to be formulated in order to describe standards of Non-hierarchical Regional Production Networks and to subsequently develop concepts, methods and instruments for generating and operating such networks.

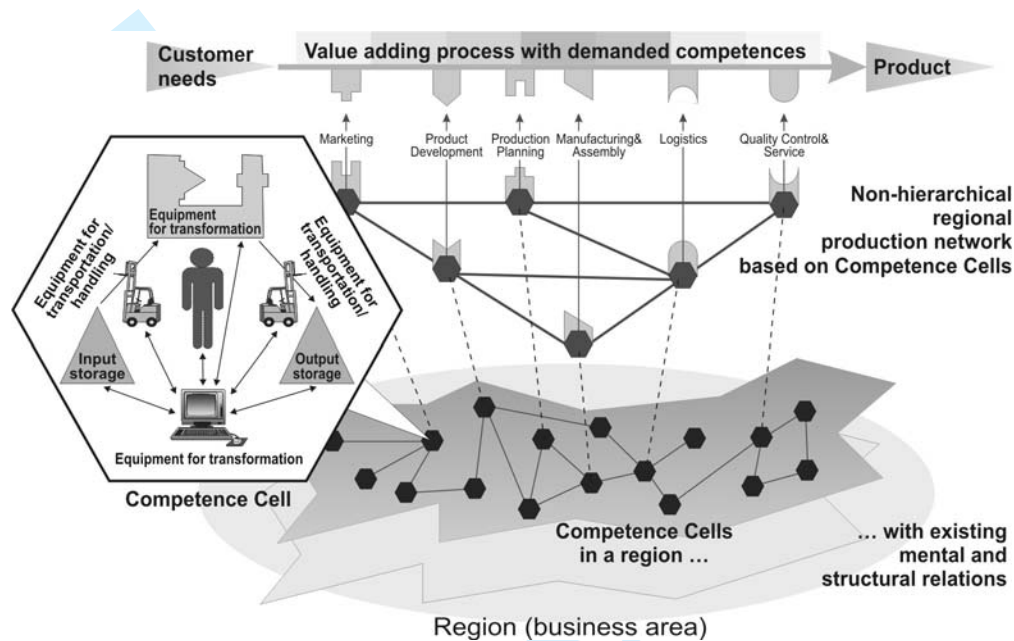


Figure 2. Conception of Non-hierarchical Regional Production Networks (SFB457 1999)

This concept also points out perspectives for present-day small and medium-sized enterprises and among them especially micro firms to face ever-changing economic conditions. Such structures of the value adding process are contributing to the development of sustainable regional production profiles. (SFB457 1999)

Objects of research are determined by the customer-oriented single piece and small-batch production conducted by mechatronical engineering companies and regional profiles.

In recent years an increasing attention has been paid to 'Collaborative Business Networks' (COBTEC) (COBTEC 2005), 'Virtual Organizations' and 'Virtual Organization Breeding Environments' (ECOLEAD) (Camarinha-Matos *et al.* 2005) especially in European research projects. Often similar assumptions to those of the vision of Competence-cell-based Networks have been made. All these research projects are striving for new forms of organisation which meet the new opportunities provided by working together in networks of production. However the central features of the Competence-cell-based Networking Approach – elementarity and autonomy of the performance units as well as the lack of hierarchies and the regionality of the networking – are not explicitly investigated. The focus of these projects is rather on supra-regional, hierarchical value adding organisations with special emphasis on the aspect of information and communication technology.

3 Models of Competence Cell and Networking

3.1 Competence Cell

A Competence Cell is considered as smallest autonomous indivisible performance unit (able to live independently) of value adding. Because of its small size the human competences are obtaining crucial importance, putting the human to the centre of the Competence Cell.

There are different types of Competence Cells, covering the whole value adding process (See figure 2). Among them are Marketing Competence Cells, Product Development Competence Cells, Production Planning Competence Cells, Manufacturing Competence Cells, Assembly Competence Cells or Quality Control and Service Competence Cells. On the subject of planning of logistics structures and production plants, Logistics Competence Cells and Production System Planning Competence Cells are of special interest.

The CRC 457 developed a generic model of the Competence Cell (figure 3) based on general production theory, specific networking requirements and investigations into the business processes of marketing, product development, production planning, manufacturing&assembly, logistics and quality control&service.

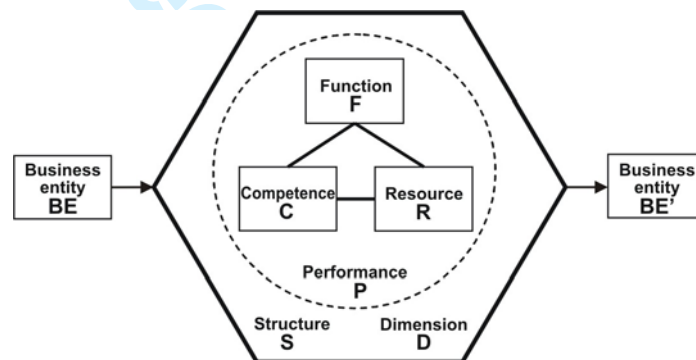


Figure 3. Generic model of the Competence Cell (SFB457 2002)

This model consists of:

- the competence of humans, arranged according to professional, methodical, social and personnel competences (Erpenbeck 1998),
- available resources as well as
- the fulfilled task or executed function.

With this function a business entity is transformed and a certain performance is achieved. For a complete technical description the aspects of dimension and structure were supplemented. The human is in the middle of the Competence Cell. Because of its small size the human competencies obtain crucial importance. Function, competence, resource and marketable performance serve as criteria to further operationalise the required decomposition of the Competence Cell.

3.2 Networking

In order to substantiate the vision of Competence-cell-based networking a Procedure Model (SFB457 2002) was developed (figure 4) which is based on the organisational concept of the Two-Level-Cooperation (Baum and Dammann 2001). The model consists of three levels and seven phases between the levels.

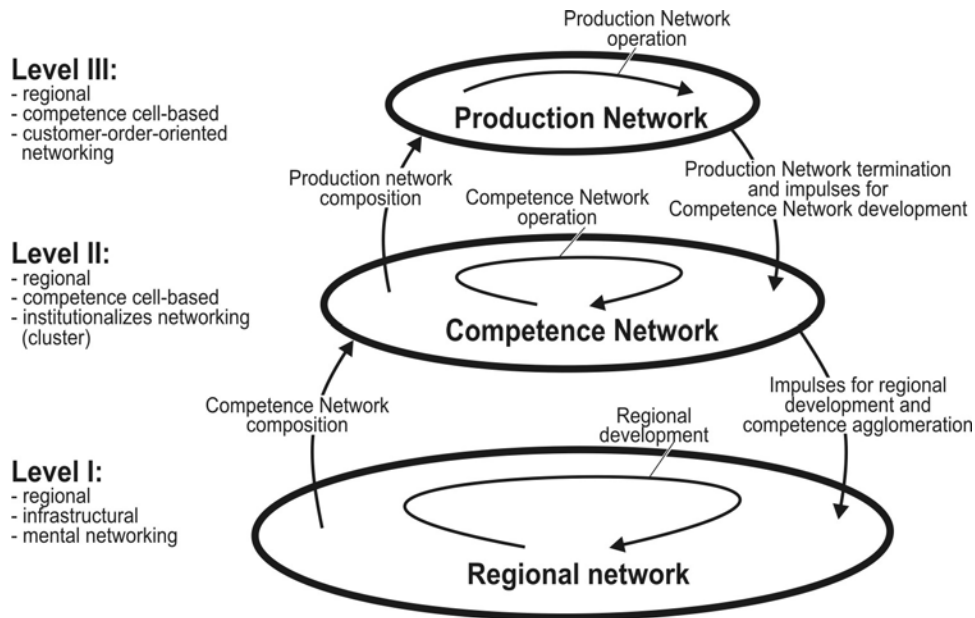


Figure 4. Procedure Model of Competence-cell-based networking (SFB457 2002)

From loose infrastructural and mental relations in a regional network (Level I) there initially emerges an institutionalised Competence Network, based on Competence Cells (Level II).

Institutionalisation takes place via the coordination of behaviour (e.g. agreements on offer generation, agreements on cost allocation) and via the pooling of capacity (e.g. common servers and data bases). These facilitate an efficient acting towards the customer and avoid internal discrepancies. Institutionalisation thereby creates the basis on which autonomous Competence Cells join to get to a collective creation of value. In order to hold fixed expenses down, the institutionalisation is to be limited to the necessary amount.

The actual creation of value takes place in a Production Network (Level III), i.e. a temporary linking of selected Competence Cells, initiated by customer request. In order to select and cross-link Competence Cells and to operate the network, co-ordinated ways of behaviour and pre-installed structures are available in the Competence Network. (SFB457 2002)

4 Holistic Integration Method

For running the innovative type of cooperation 'Non-hierarchical Regional Production Networks' an operationalised concept of organisation is needed. Such a concept was developed with the 'Holistic Integration Method' (HIM). HIM marks a comprehensive instruction as a kind of organisational manual for the Competence Cells. It is based on the levels and phases of the Procedure Model (figure 4). The general architecture of the Holistic Integration Method consists of the levels 'Portal', 'Process Engine' and 'Methods and Tools' as illustrated in figure 5.

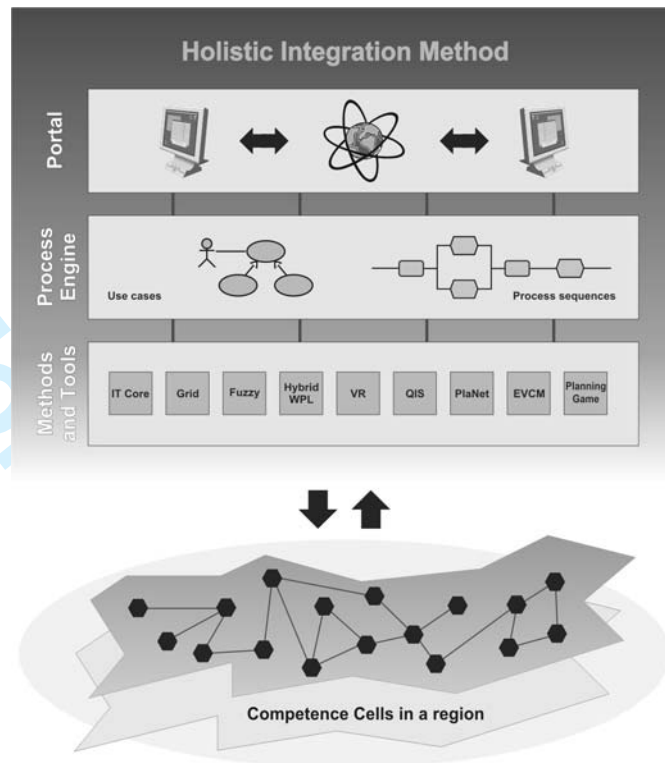


Figure 5. Architecture of the Holistic Integration Method (SFB457 2005)

The Competence Cells as users access the functions of HIM through a web-based portal. The access is supported by a Dynamic Concept of Roles. This concept of roles meets the different cooperative job contents respectively views of the users on the processes in Competence and Production Networks. The portal is planned as a web-based application which assists the user with his cooperative tasks. For example access to immediately needed documents and papers is provided and the starting of problem-specific software tools is enabled through the portal.

This becomes possible through directly linking the portal to the 'Process Engine'. On the highest level of the Process Engine typical cooperative use cases respectively procedures inside the levels and phases of the Procedure Model as well as the link to suitable methods for the solution of this cooperative task are defined. A description of those can take place in several levels of detail depending on the complexity of the use case. In the lowest level the different methods are described in an application-driven form and if applicable linked to supporting software tools. The dynamic aspect of this Process Engine consists of its workflow function. The most important criterion is the distinction between strongly-structured and weakly-structured processes. Strongly-structured processes are mainly technical processes for which the definition of process sequences for the different use cases and their variants is possible. Besides milestones, at which the workflow reaches a defined state, can be defined for this kind of process. Weakly-structured processes are usually processes of administration, i.e. processes of communication and coordination inside the Production and Competence Network. The description of comprehensively defined process sequences is not or only partly possible for this kind of processes.

The Holistic Integration Method is intended as a kind of organisation manual which provides the Competence Cells acting in the network with options for handling a specific use case. Through the HIM it will be possible

1
2
3 to implement a well directed transfer of information between the Competence Cells both in the level of the
4 Competence Network as well as in the level of Production Network independent from time and location.
5 In the level 'Methods and Tools' a detailed user-friendly description of the different methods as well as
6 linkage to the supporting software tools is provided. (SFB457 2005)

7
8 The IT Core (Neubert *et al.* 2001), the Extended Value Chain Management (EVCM) (Görlitz *et al.* 2002) and
9 the Planning Concept for Networks – PlaNet are among the components of the Holistic Integration Method.

10 The IT Core is storing the self-description of Competence Cells. Requirement vectors are defined if
11 Competence Cells are needed for a particular task. Candidates for executing those tasks are found through the
12 matching of the description with the requirements. EVCM including the business logic is the implementation
13 of the operator concept of Competence-cell-based Networks.

14 PlaNet, will be introduced in more detail in the next chapter, at the same time giving an example of the
15 functioning of the HIM.
16
17

18 **5 PlaNet – a planning concept for networks**

19 20 21 **5.1 Requirements on planning of logistics structures and production plants in Competence-cell-based** 22 **Networks**

23
24
25 The approach of Competence-cell-based Networks has in several respects drastic impacts on planning and
26 design of the logistics structures and production plants in such networks. From the Competence-cell-based
27 Networking Approach the following substantial questions for the method and object domain result:

- 28 • Which methodical concept is suitable for the planning of the logistics structures of Competence Cells
29 cross-linked to production systems as well as for the planning of network-able production plants?
- 30 • Which design solutions for logistics structures and production plants can be derived from the
31 Competence-cell-based Networking Approach?
32

33
34 Planning of logistics structures and production plants in Non-hierarchical Regional Production Networks
35 leads to new requirements. At the same time general trends in factory planning and logistics need to be taken
36 into consideration. Differences to classical planning approaches are among others:

- 37 1. Competence-cell-based Networks are subject to a constant change. They need to be able to respond
38 permanently to customer demands. Thus a permanent readiness for planning, inducing a unity of planning
39 and control, is necessary. This includes also a demand for high flexibility.
- 40 2. Since there is a vast diversity of planning problems the typical planning cases are to be recognized and
41 systematised.
- 42 3. So far only production plants have been considered in planning, while the object domain considered in
43 Competence-cell-based production systems is significantly wider. The objects of planning, which can be
44 derived from the model of the Competence-cell-based production system (SFB457 2002), comprises
45 different networks with Competence Cells as network nodes as well as the regional production
46 infrastructure with its adjusted production plants.
- 47 4. The changed object domain of planning has also an impact on the method domain. Appropriate planning
48 methods need to be provided.
- 49 5. Networked Competence Cells are subjects (actors) as well as objects of planning. This means, that the
50 Competence Cells often need to solve their planning problems themselves in the sense of self-
51 organisation. Hence it is necessary to support the planning conceptually and instrumentally, enabling
52 'Non-planners' to carry it out.
- 53 6. Due to the absence of hierarchies decisions have to be worked out in teams and with mutual consensus
54 based on partnership.
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7. Methods need to be adapted, which reduce the risk of higher expenses for planning because of modifications in late stages of planning, through the shift of planning functions to earlier stages, thus increasing the confidence of planning.

Classical planning approaches deal however with hierarchical structures and persisting manufacturing systems. They can meet these requirements only partly. Therefore a new framework for planning in networks of competence is needed. Such a framework is being developed with the PlaNet.

5.2 Contents of PlaNet

PlaNet is meant to enable and support Competence Cells in solving different planning problems in the field of logistics structures and production plants in Competence-cell-based production systems, so that they can plan networks in case of need as well as in advance.

PlaNet was designed as a framework, which embraces suitable theories, models, concepts, methods and preference solutions for logistics structures of Competence Cells linked to production systems as well as the planning of network-able production plants (figure 6).

The theories, models, concepts and methods of PlaNet can be adopted from other scientific fields such as computer science or operations research as well as from the related fields of factory planning, production planning and control (PPC) as well as logistics, of which the Competence-cell-based Networking Approach is a special area of research. Among the included theories is the system theory, while a production data model and business process models represent included models. A deployed concept is the Systems Engineering Methodology (SE) (Daenzer and Huber 1994).

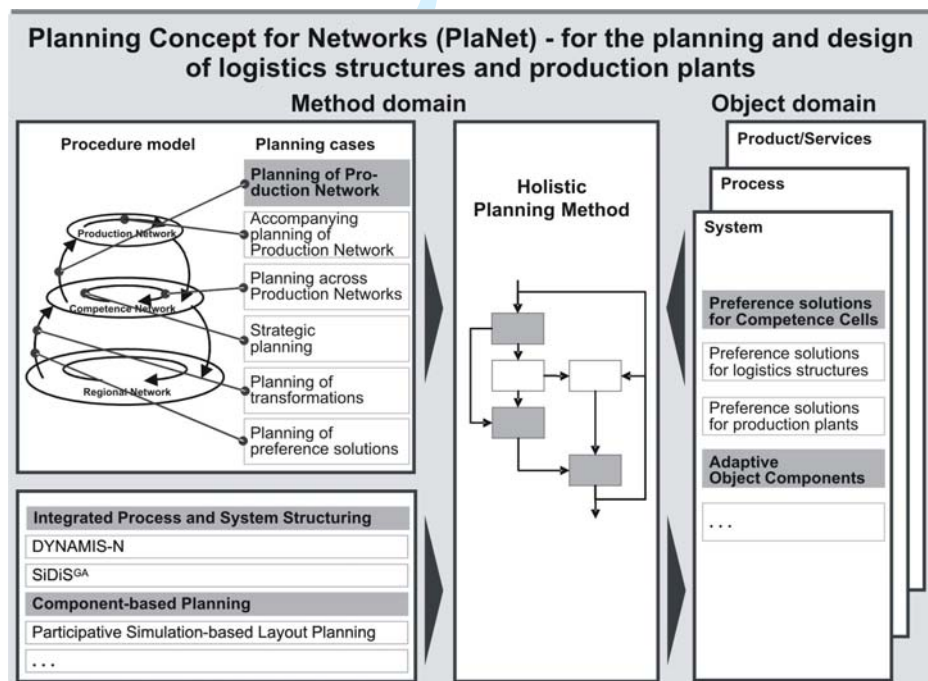


Figure 6. Planning concept with Holistic Planning Method (SFB457 2002)

This framework features a methodical concept with which adapted design solutions for logistics structures and production plants can be generated. A Holistic Planning Method integrates methods and components

depending on the specific planning problem. Both Competence Cells with special planning competences and Competence Cells without such competences are addressed by PlaNet.

5.3 Methodical concept

In the further course for the development of the methodical concept existing problem solutions and planning approaches were assessed regarding adequacy with catalogues of requirements/criteria and SWOT analysis. After detailed assessments the universal, domain-neutral, flexible and adaptable concept SE proved to be a suitable basis. If the components of SE are considered as framework for PlaNet, the respective specific components of the methodical concept of PlaNet can be classified in this framework (figure 7).

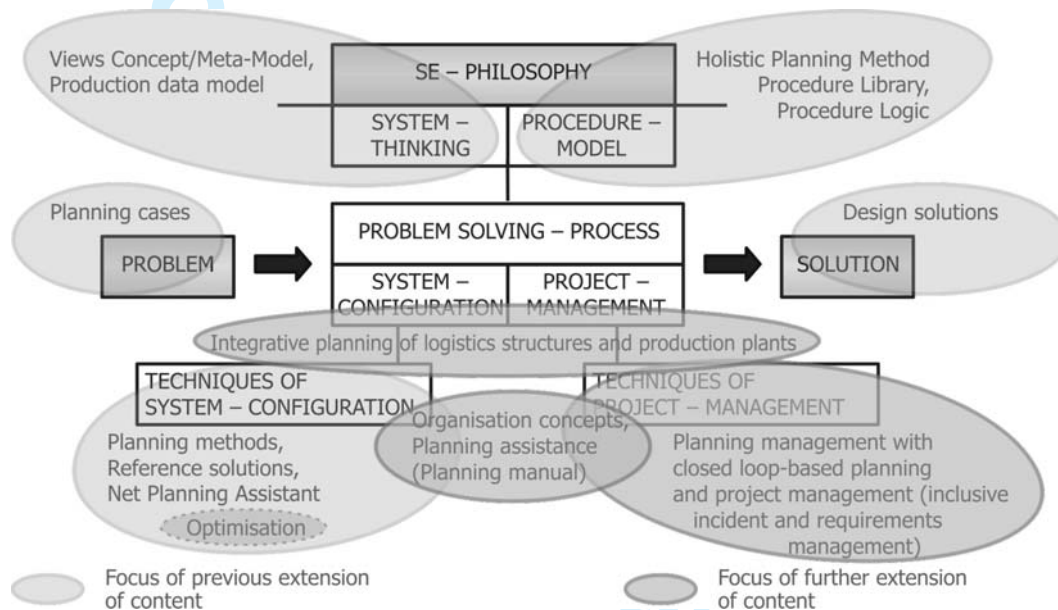


Figure 7. Systems Engineering as framework for PlaNet (SFB457 2005)

5.4 Selected components of the methodical concept

5.4.1 Procedure Logic

The methodical concept of PlaNet, basically represented by the Holistic Planning Method, follows substantially the Proceeding Logic which is outlined in figure 6 (SFB457 2005).

As a first step a systematisation of the planning problems or use cases – called planning cases – for the system under investigation has to take place. This needs to be done usually only once for a certain object domain, here Competence-cell-based Networks. Procedures for typical planning cases are determined then. There might be more than one procedure for a particular planning case. The planning instance can decide which procedure is appropriate for the actual situation in which the planning case appears. Such procedures are collected in a Procedure Library.

Once an impulse for planning has been given the relevant planning case has to be determined. If it is one of the typical planning cases a proper procedure can be obtained from the Procedure Library.

1
2
3 There might be a need to adapt the chosen, rather general procedure to the special situation in which the
4 planning case occurs. The conceived planning process contains the particular planning steps which need to be
5 processed. The relevant input and output data, the appropriate methods and instruments as well as the typical
6 roles/actors are assigned to the steps. The methods, depending on the respective planning case, use 'pre-
7 configured' ideal-typical solutions in the object domain, such as preference solutions for Competence Cells
8 and logistics structures or adaptive components of production plants.

9
10 Finally the elaborated procedure can be executed and the planning problem will be solved.

11 Those steps, building on each other, can be repeatedly executed, accompanied by project management.

12 If the planning case is not among the typical ones however, usually a procedure has to be found first. This
13 procedure can be eventually included in the Procedure Library and thus it can be used again should the
14 underlying planning case reoccur.

15
16 If there is no procedure for a particular planning case at least one has to be elaborated. General procedure
17 models including the problem solving cycle can provide a good pattern for this.

18 By this instruction the Competence Cells are equipped to solve the planning case, processing the different
19 planning steps.

20
21 The Holistic Planning Method comprises the specific procedures to an overall general procedure, including
22 proper general workflows such as the phase cycle model and the problem solving cycle of the Systems
23 Engineering Methodology (Daenzer and Huber 1994).

24 It guarantees a uniform approach to all planning cases and therefore has to be universal and variable. The
25 planning method and hence also PlaNet have a modular structure in order to reduce complexity and increase
26 flexibility. The core process of planning is characterised by back coupling between the planning steps and
27 their iterative cyclical processing. Thus the Holistic Planning Method constitutes the core of PlaNet.

30 31 **5.4.2 Planning cases**

32 A part of the methodical concept is the systematisation of typical planning cases. Clues for the systematisation
33 are provided by the phases of the Procedure Model or the demanded input respectively the desired output.

34 There is a vast number of planning cases concerning logistics structures and production plants in Competence-
35 cell-based Networks. Through restraining to essential properties of the domain under consideration however,
36 which can be derived from the developed models, frameworks or approaches, the number of relevant planning
37 cases can be restricted to a manageable amount. If a further restriction to typical planning cases with a high
38 probability of repetition is enforced, the number of planning cases can be reduced to a quantity which can be
39 handled.

40
41 Therefore after the definition of the term 'planning case' and the elaboration of requirements on the
42 structuring of the planning cases a framework based on SE and its problem solving process was created for
43 the structuring of planning cases including the derivation of essential properties. According to this the
44 properties of the planning cases can be assigned to the groups problem domain, ways of solving and solution
45 domain (figure 8). Independent properties as well as properties which depend on the domain can occur in the
46 groups of properties in different levels of abstraction. For the detailing of the immediate sub-level of
47 abstraction the essential properties need to be determined. With this flexible and adaptable conception, based
48 upon the morphological-typological method, the integrative treatment of planning cases in the fields of
49 logistics structures and production plants is prone to succeed.

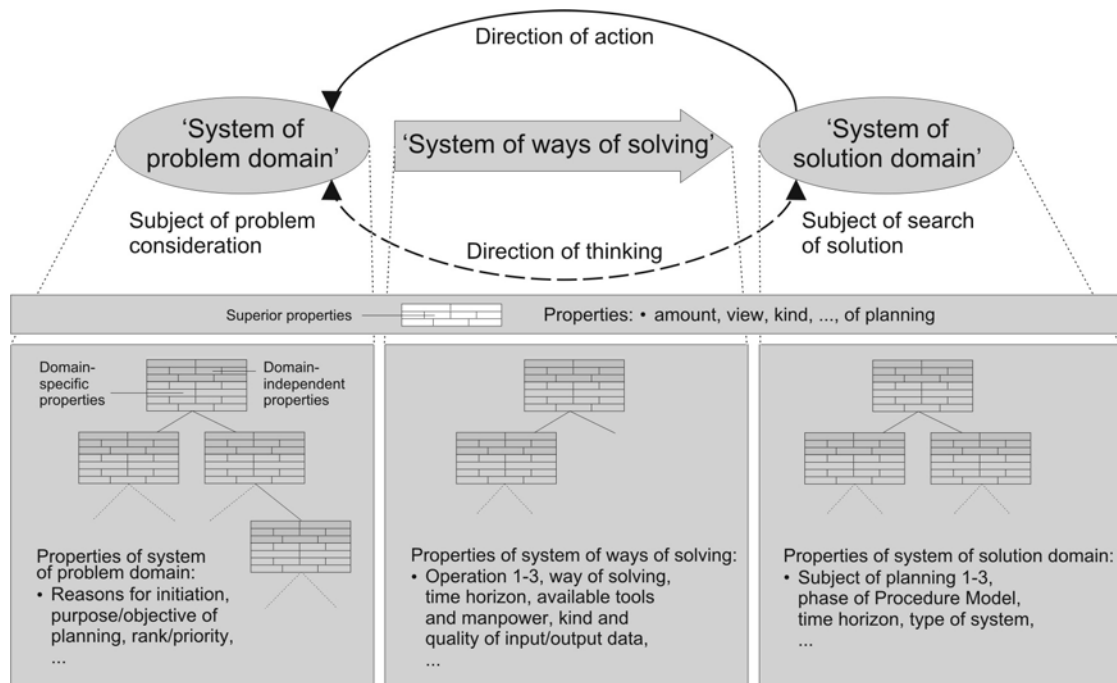


Figure 8. Framework for the systematisation of planning cases (SFB457 2005)

The classification and standardisation has to be done once per domain which is in this case logistics structures and production plants in Competence-cell-based Networks. Procedures with attached methods (e.g. task analysis) have been developed for these tasks as well as for the necessary identification of a particular planning case which has just occurred (figure 9). The developed procedures have been modelled with the ARIS-Toolset modelling software. This leads to a further methodical support and increase of flexibility compared to fixed morphologies/typologies of planning cases. In case of need (such as a modification of the domain) the extensive procedure of classification and systematisation of the planning cases can be executed again. The structure of the resulting two procedures adopts the structure of the Holistic Planning Method. (SFB457 2005)

5.4.3 Holistic Planning Method

Specific procedures of planning result from the respective planning cases. The Holistic Planning Method as the procedural core of PlaNet constrains those to a unique pattern. Therefore it needs to be properly universal and variable. In order to reduce complexity and gain flexibility the Holistic Planning Method and therefore also PlaNet should feature a modular construction.

Despite the fact that planning as creative process is hard to be pressed into an algorithm and often is characterised through the iterative cyclical processing of planning steps, the specific procedures can be abstracted to a superior general procedure under inclusion of suitable general sequences such as procedure models or problem solving cycles. In result the Holistic Planning Method is based on the phase cycle model of SE, consisting among others of preliminary study, main study and detailed study (figure 9). Inside the particular phases the problem solving cycle serves as micro-logic.

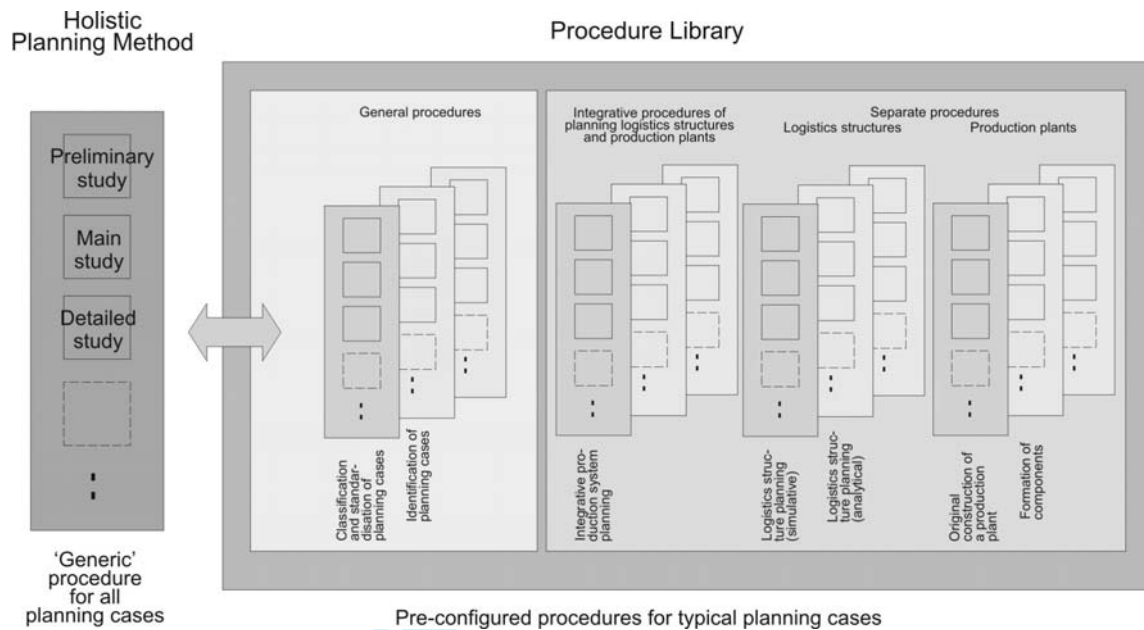


Figure 9. Holistic Planning Method and Procedure Library (SFB457 2005)

The development and storage of procedures for typical planning cases can be carried out adjusted to the general structure of the Holistic Planning Method, possibly in variants and different degrees of detailing. The 'Pre-configuration' of procedures for such planning cases featuring a high probability of repetition and their storage in a Procedure Library (figure 9) is on the one hand extensive on the other hand it leads however to for Competence-cell-based Networks essential rationalisation, simplification and acceleration of the planning process. Besides, proven and situational adapted procedures should be included in the Procedure Library in the sense of best practise solutions. This way the library is subject to a constant updating and enhancement. The construction of the library took place by means of the modelling system ARIS-Toolset as Process Selection Matrices linked to Function trees, extended Event-driven Process Chains (eEPC) etc.

Different methods and reference solutions for the planning of Competence-cell-based production systems can be integrated in both, the Holistic Planning Method as a Meta-Method as well as the procedures which were designed by its pattern. (SFB457 2005)

Besides established methods adapted to the planning of Competence-cell-based Networks the following tailored methods for the planning of logistics structures and production plants in such networks are developed (See figure 6):

- The Method of Integrative Process and System Structuring (Müller and Ackermann 2005) and
- the Method of Component-based Planning (Näser 2005).

5.4.4 Principles of planning

Planning principles are generalised cognitions or experiences which are simple rules of planning. Planning principles are a component of a planning methodologies' theoretical basis (See Rockstroh 1977, Schmigalla 1995).

Planning principles for conventional production systems were analysed and assessed in respect to their applicability on Competence-cell-based production systems. Thus planning principles for networks could be formulated, presenting an important component of the methodological concept of PlaNet. The following selected general principles hold also for planning of logistics structures and production plants in Competence-

cell-based Networks: principle of complexity, principle of levels and variants, principle of ranking and unification (common terms, element breakdown and structuring, principle of building blocks, limitation of types, scales), principle of project constancy, principle of minimisation of interfaces, principle of piecemeal engineering, principle of minimal bias, principle of modular structure, principle of iteration, principle of parallelisation, principle of decentralisation. (See e.g. Daenzer and Huber 1994, Eversheim and Schuh 1999, Rockstroh 1977, Schmigalla 1995)

In addition to those general principles a number of principles for planning result from the special domain of Competence-cell-based Networks and the methodological concept of PlaNet. Those are among others: principle of permanent and continuous planning, principle of focussing on typical planning cases as well as pre-configuration of (sub-)solutions and planning-case-dependent configuration of planning processes, universality of the planning methodology, evolutionary planning (e.g. recordation of best-practise-procedures), principle of transparency and objectivity of planning, self-organised planning, cooperative planning without the possibility to give orders, forward displacement of planning functions, integrative, participative, holistic, integrated planning. (Müller *et al.* 2004)

Those principles of planning in networks provide orientation to the Production System Planning Competence Cells and all other actors of the planning process, influence the determination of an approximately optimal planning solution positively and will be included in the planning manual which will be conceived.

6 Net Planning Assistant

The Net Planning Assistant (figure 10) is the implementation of PlaNet into a planning instrument which can be used by planners as well as non-planners (Müller *et al.* 2004).

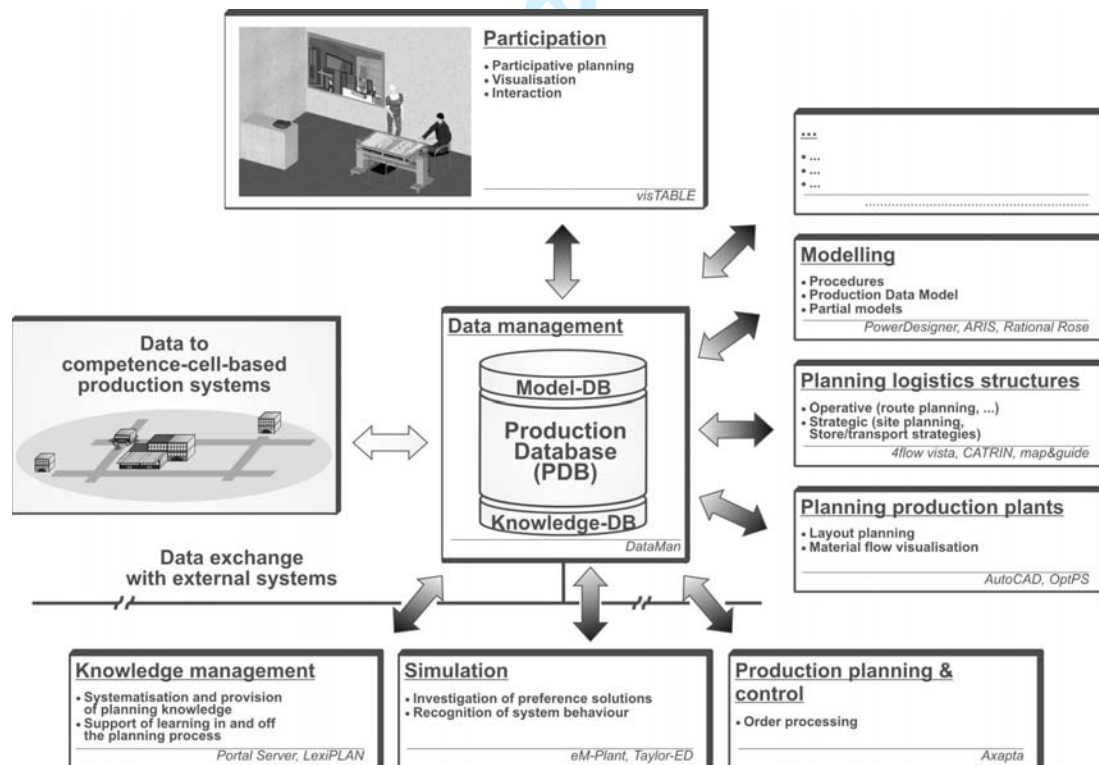


Figure 10. Net Planning Assistant (Müller *et al.* 2004)

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3 Besides general requirements on software, additional requirements rise from special aspects of Competence-
4 cell-based Networks. Those are the consideration of missing planning competences in non-planning
5 Competence Cells, small funds and heterogeneous software environments. On the other hand a holistic
6 approach, internet-based connecting of Competence Cells and Participative Planning should be pursued.

7 Especially participative planning is qualified for the solution of typical network-relevant planning cases. The
8 human is in the centre of networks of Competence Cells. Since there are non-hierarchical structures decisions
9 have to be made on equal rights. Through the determination of the business processes with their input data,
10 output data and actors, tasks which need to be done in a participative way can be recognized. Examples of
11 such tasks are planning of a production plant through a Production System Planning Competence Cell
12 together with the Manufacturing Competence Cell concerned, the synchronisation of manufacturing and
13 logistics through the respective Competence Cells or the design of the logistics structures inviting the
14 involved Logistics Competence Cells.

15 There are two possible scenarios in participative planning. It can be done in a central meeting of all
16 participants as well as with participants at different locations through the internet.

17 Competence Cells with different levels of planning competence, the Competence Cells concerned by the
18 planning as well as external partners and customers unite in the process of participative planning. This leads
19 to an acceleration of the planning process, an improvement of the quality of planning, an increase in
20 confidence through grouping of diversified planning expertise as well as an increase of the acceptance of the
21 planning results. The Net Planning Assistant will contain functionality which supports participative planning.

22 Analogue to PlaNet the Net Planning Assistant has a modular structure. Hence it can be guaranteed that the
23 Competence Cells are provided with compatible software components, depending on their special problems.

24 The Net Planning Assistant is based on the findings of an earlier research project (Wirth *et al.* 2000). Through
25 respective interfaces a bi-directional data exchange between the production database and the employed
26 components for visualisation, planning and simulation can be secured. Therefore a concept for interlinking
27 software for the data exchange between different commercial and self-developed software components
28 through an adaptation layer has been created. This resulted in the planning system 'Planungssystem 2000+'.
29 According to their tasks the Competence Cells are then enabled to configure a tailored software package. The
30 Net Planning Assistant is the consistent further development of this planning system according to the
31 requirements of planning in Competence-cell-based production systems. Parts of it are now introduced briefly.
32 The core of the Net Planning Assistant is the Production Database (PDB). The PDB is based on a production
33 data model. It has been adapted to the needs of Competence-cell-based production systems. The PDB is the
34 main database in which all relevant information about production and logistics is modelled. Especially
35 changes through the novel organisation structure of Competence-cell-based Networks require modifications of
36 the database model. Since the whole value adding chain is investigated resources and processes are to be
37 taken into consideration which used to have no significance for planning at a singular location. The data
38 model of the PDB is developed with a CASE-tool so that it is independent of any particular Database
39 Management System (DBMS). Besides a Data Definition file (*.dtd) for the Extended Mark-up Language
40 (XML) can be generated, which will be useful for developing a uniform interface.

41 The user interface for the administration of the PDB and the data exchange with various information systems
42 is compressed in the data management tool DataMan. It provides an intelligent portal, with which teams are
43 connected and information can be shared. Through the internet it can be accessed worldwide. Besides
44 providing user interfaces for the manipulation of the data, some basic planning functions can be executed with
45 DataMan. Through linkage the interfaces for the data exchange with the different software tools can be
46 started.

47 Route planning and optimisation software will be used for planning and optimisation of logistics structures,
48 especially involving Competence Cells at different geographical locations. The generated preference solutions
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3 for logistics structures and production plants have to be assessed through simulation, based on different
4 scenarios. For this automatic layout generation ought to be further developed. Routing software needs to be
5 directly embedded in order to determine the shortest paths. To assist the team-oriented design of the layout of
6 logistics structures and production plants the development of the planning and visualisation tool visTABLE
7 (Müller *et al.* 2004) will be advanced.

8
9 A knowledge management system will support the administration and displaying of the expertise which is
10 necessary for the planning in Competence-cell-based Networks. Thus the Competence Cells will be supported
11 in finding appropriate procedures and methods for the solution of its upcoming planning problems.

12 Production Planning and Control (PPC) applications should be included for several reasons. The data of
13 existing enterprises can be extracted. On the other hand the results of the planning need to be transferred to
14 the Competence Cells which will use PPC later. Additionally the impact of planning decisions can be assigned
15 with the PPC system in a simulative way.

16
17 The empty box in figure 10 symbolises the open concept of the Net Planning Assistant which allows to add
18 solutions for future planning tasks which are not covered by the current classes of tools.

19 The Net Planning Assistant is incorporated in a field of experimentation, which was developed in the CRC
20 457 to conduct investigations on prototypes.

21 22 23 **7 Conclusions and outlook**

24
25 A couple of surveys have proven the growing importance of micro-enterprises. Competence-cell-based
26 Networks provide a promising approach for future forms of value adding organisations, Competence Cells
27 being comparable to micro-enterprises. This approach also points out perspectives for present-day small and
28 medium-sized enterprises to face ever-changing economic conditions.

29 The 'Holistic Integration Method' (HIM) is the suitable operationalised concept of organisation in such
30 networks, providing the Competence Cells with an organisational manual.

31 The Planning Concept for Networks – PlaNet as a component of HIM, meets the special requirements on the
32 planning and design of logistics structures and production plants in Competence-cell-based Networks. It is a
33 framework which includes adequate methodical and default components for planning and design logistics
34 structures and production plants. Based on the Systems Engineering Methodology, PlaNet with its methodical
35 concept contains a number of components such as the Holistic Planning Method and the Procedure Library.
36 Through those components PlaNet assists Competence Cells with the solution of their planning cases.
37 Additional components such as planning management or incident management will be subject of forthcoming
38 research.

39 The suitable toolset for the IT-support of distributed planning is the Net Planning Assistant, the
40 implementation of PlaNet. The demand for flexible and integrative planning is satisfied through its modular
41 structure, a central common production database, a consistent interface concept and the possibility to
42 incorporate any appropriate software tool. Concepts for effective shared utilisation of the Net Planning
43 Assistant are of great interest for future research.

44 45 46 47 48 **8 Acknowledgements**

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