Planning of large-scale logistics sites

Jochen Kreutzfeldt
Professor
Hamburg University of Technology
Institute of Technical Logistics

Philipp Braun
Research Assistant
Hamburg University of Technology
Institute of Technical Logistics

Jakob Schyga
Research Assistant
Hamburg University of Technology
Institute of Technical Logistics

Svenja Hilbrich
Research Assistant
Hamburg University of Technology
Institute of Technical Logistics

Johannes Hinckeldeyn
Chief Engineer
Hamburg University of Technology
Institute of Technical Logistics

Planning projects of large-scale logistics sites are often characterized by several stakeholders, planning data of limited initial quality and a high number of planning decisions. These specific attributes can lead to uncertainties in terms of stakeholder interests, responsibilities and planning information. Existing methodologies operate mainly in stepwise approaches and cannot always fulfil the requirements of complex plannings and decision-making under uncertainty sufficiently. This paper proposes a new planning framework with regard to insights from several industrial planning projects. The proposed framework starts with a stakeholder analysis and the definition of a planning codex. All subsequent planning decisions are structured in a flexible decision-making network. Lastly, the planning framework is applied to an exemplary planning project.

Keywords: *Logistics site planning, warehouse planning, planning uncertainties, stakeholder analysis, planning objectives, planning structures, planning decisions.*

1 INTRODUCTION

In a planning project objectives and necessary actions are systematically defined and realized. For logistics sites planning actions include e.g. the designation of processes, site and building surfaces and storage technologies.

There can be various reasons for the planning of a logistics site. Besides the demand for higher capacities, the wish for the optimization of processes, the availability of technical innovations as well as new laws or regulations may result in the requirement for a new or modified logistics site [9].

The planning of a logistics site is a demanding task. Complex company structures, a diversity of involved stakeholders, limitations in the availability and quality of planning data and a broad range of potentially applicable transport and storage technologies lead to uncertainties and challenges in the planning of large-scale logistics sites. To handle this complex task, a structured planning process is required.

Existing planning methodologies for production and logistics sites have shown deficiencies when it comes to deal with the uncertainties of large planning projects. These uncertainties can be driven by new stakeholders entering the project or the integration of new planning data and knowledge in later project phases.

Therefore, based on experiences from industrial projects, an improved approach for the planning of logistics sites was developed. This approach presented in this paper extends the current methodologies to minimize uncertainties and for dealing with them.

It is proposed to form a planning codex at the very beginning of the project. This planning codex is the result of bringing together and balancing the interests of the project stakeholders identified in a preceding stakeholder analysis.

The planning codex is made up by a vision for the envisaged logistic site and a number of corresponding planning guidelines. For each planning guideline potential realization measures are indicated. At this early project stage, the measures are not decided yet. Their definition serves rather to support an understanding of the defined guidelines and opens the eyes for potential solutions. The project codex shall ensure that the diverse interests of the various stakeholders are taken into account consequently not only at the project start but during the entire project run time.

A dynamic planning framework is proposed integrating both the stakeholder analysis and the planning codex in order to handle uncertainties in planning steps. To identify and evaluate realization alternatives a decision-making process is suggested.

In section 2 an overview on existing methodologies and their limitations is given. This is followed by an analysis of uncertainties in the planning process in section 3. The developed planning framework is described in section 4 and an exemplary planning process based on a selected industrial project presented in section 5. The article is closing with a conclusion in section 6.

2 PRODUCTION AND LOGISTICS SITE PLANNING METHODOLOGIES

The existing literature on the planning of production and logistics sites is extensive.

Today’s planning methodologies are mainly based on a hierarchical approach combined with the willingness for an iterative advancement in case unsolvable challenges or unsatisfying results occur on a lower planning level. The well-known methodologies organise the planning process in idealised process steps of project setup, structuring, system design and usually end up with a realization phase.

Correspondence to: Prof. Dr. Jochen Kreutzfeldt
Institute of Technical Logistics,
Theodor-Yorck-Straße 8, 21079 Hamburg, Germany
E-mail: Jochen.Kreutzfeldt@tuhh.de

The actual state of planning methodologies in literature is presented in the succeeding subsections.

Meanwhile, industrial projects have been following agile and iterative procedures different to classical sequential approaches.

2.1 Existing production and logistics site planning methodologies

Production and logistics site planning methodologies are dealing with the design of appropriate processes and storage systems under consideration of various and competing system alternatives. Therefore, planning activities need to be carried out in organizational, technical and economic areas of planning to provide a comprehensive concept [4]. These activities aim at improving current operations and overcoming historically grown structures by developing new solutions [6]. Possible planning situations vary from the design of new sites, extensions, site reconstructions to revitalisations [9]. To select the optimal solution from the pool of alternatives for the different objects and systems within the planning project, the planning should be executed in an iterative and systematic way. Moreover, planning procedures must offer flexible, adaptable and explicit procedures [6].

Figure 1 summarizes actual planning methodologies for production and logistics sites. These can be clustered into the four phases project setup, structuring, system design and realization. The presented methodologies suggest a more or less sequential set of steps for planning projects with varying levels of planning detail.

The first phase is usually described as the project setup phase. The project setup starts with the definition of planning objectives [5], [9]. This includes the definition of tasks included in the scope of the planning. The result is a clear defined project structure supporting efficient procedures in following project phases [10]. Subsequently, the data analysis aims to determine the starting situation, future performance requirements and boundary conditions. In practice, conducting this data gathering task can be especially time-consuming. Additionally, a feasibility study to further confirm the planning objectives may be conducted [6].

The second project phase is called structuring and aims at creating a holistic concept of the future production or logistics site, which is able to achieve the predefined objectives. Therefore, production and logistics principles, corresponding functional and organizational units and respective processes of the future production or logistics site are to be defined [10]. Surfaces, equipment and personnel requirements must be determined and dimensioned [11]. Under consideration of boundary conditions such as building specifications, system and processes alternatives are generated and evaluated. This phase results in a decision for a future system solution based on a quantitative and qualitative evaluation. Subjective preferences and decisions should be avoided at this planning stage. Therefore, benefit value, profitability and risk analysis are recommended [9].

After selecting a certain system solution based on the outcomes of the systems planning during the structuring phase, the system design follows as the third project phase. In this phase, the detailed planning for the selected system is to be performed. Consequently, the process layout, realization and operating costs must be reassessed and time requirements for the realization of the selected system determined. In the following the industrial engineering and the preparation of calls for tender are performed. This phase delivers a system design planned in detail, if appropriate a selected systems vendor and final calculations of realization costs and time requirements.

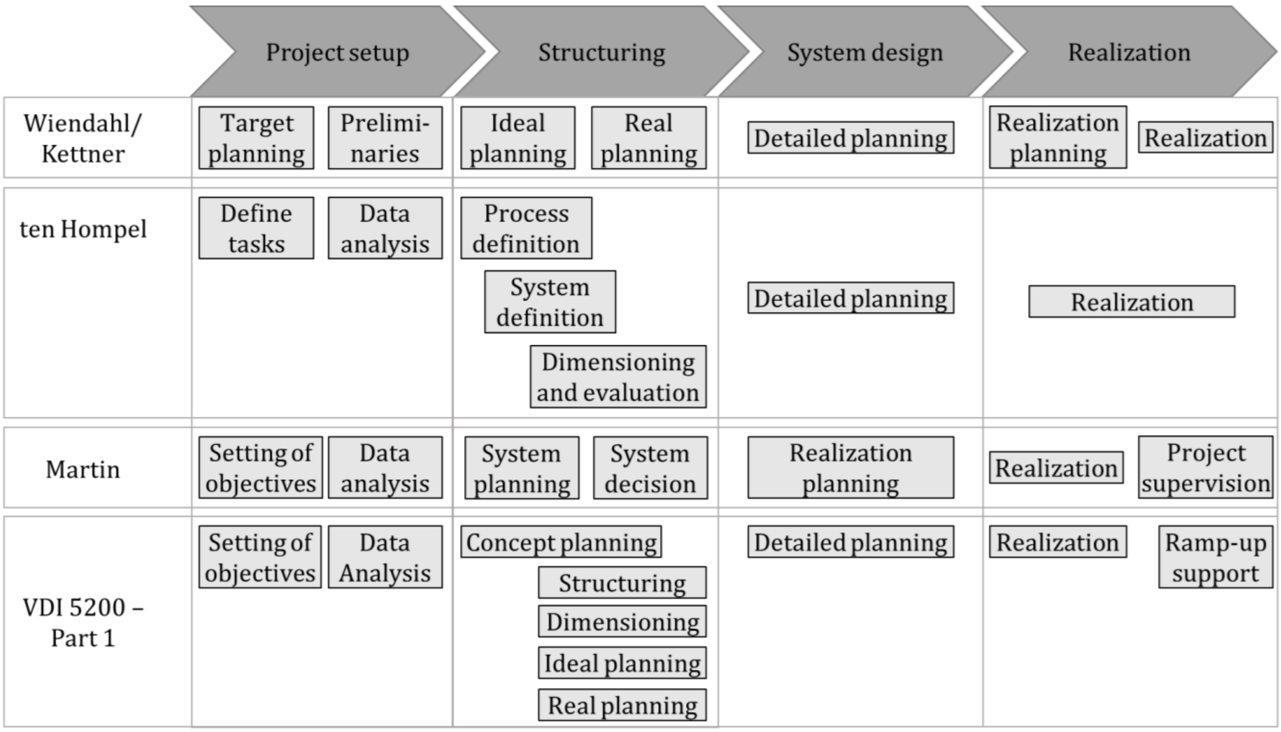

Figure 1: Production and logistics site planning methodologies in the literature [5], [6], [9], [10], [11]

After selecting an appropriate equipment supplier, the realization is carried out in the final project phase. This phase deals with the construction and supervision of all building and system sections, followed by a final project documentation and revision [6].

Most authors point out, that the stepwise planning procedures should not act as a barrier for necessary reiterations within real planning projects.

2.2 Gaps in the recent literature

Insights from several industrial projects showed difficulties in the management of dynamic project procedures. Existing planning methodologies offer sometimes limited support in the management of the practical planning tasks.

Due to the high number of alternatives for system and process solutions, logistics site planning is complex. This entails difficulties in finding an optimal solution [1]. As most authors already pointed out, reiteration is strongly necessary to overcome this problem. However, despite the recommendation for reiteration, the flexible and interrelated way of working in planning projects is not strongly integrated and supported by existing methodologies.

A wide variety of stakeholders is involved in the planning project. Figure 2 shows the exemplary involvement of stakeholders throughout the different steps of planning. All stakeholders must be integrated in the project according to their individual interests, knowledge and responsibilities. During the different steps of the planning project the stakeholders may change to some extend in every step. The dynamic composition of stakeholder groups results in different objectives, information and knowledge leading to additional complexity in the course of planning projects. This aspect has not sufficiently been integrated in current planning methodologies.

An evaluation of the planning alternatives based on qualitative criteria like flexibility and green characteristics is usually applied [9]. A common tool to carry out this evaluation is the benefit value analysis which is chosen in order to obtain objectivity and to avoid personal preferences when assessing qualitative criteria [6]. In practice, the alignment of certain decision criteria to the overall planning objectives is difficult.

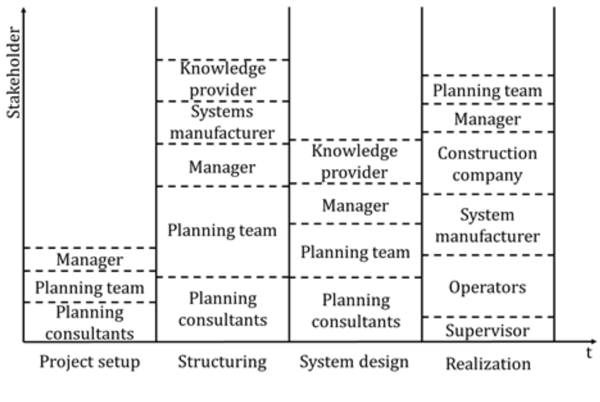

Figure 2: Idealised stakeholders per planning phase

3 UNCERTAINIES IN PLANNING

The planning of large logistic sites is characterized by a variety of uncertainties leading to excessive time consumption and high costs for planning, nevertheless sometimes to suboptimal results. Number and impact of uncertainties tend to increase with the size and complexity of a planning project. Especially for large logistic sites, it is important to reduce uncertainties and apply methods to deal with them. The aim of this section is to examine the main drivers of uncertainties. Uncertainties are categorized and approaches for minimizing or dealing with them described, which are later on integrated in the developed planning methodology.

3.1 Fields of uncertainty

As in section 2.2 described, many internal and external stakeholders are involved pursuing their own interests.

For example, despite accepted lean management principles a production function may prefer to plan with high stocks of purchased and finished goods. This is especially the case if process variances seem to endanger the aspired fast and flexible deliveries of the right amount of the right objects, packed on the right delivery unit to the right place.

At the same time, the logistics department may aim for lower logistics costs and throughput times through reduced stocks, process standardization and consistent type and quantity of deliveries to and from the logistic site. The procurement in turn wishes to purchase large quantities in high order sizes to reduce administrative efforts and purchase costs.

Furthermore, external parties such as supplier of logistic equipment or consulting companies pursue to generate a high turnover while satisfying the customer. In some cases, there might be logistic service provider involved in order to operate the site.

Partly conflicting interests lead to a wrangle between stakeholders over the influence of the planning project. Furthermore, the individual persons in each interest group cannot be considered fully objective. Their opinions depend not solely on economic principles but also on their personal experience, interests and emotions. With a higher hierarchical position of an individual this factor gains importance. For example, a powerful manager involved in an important decision can tilt the direction of the entire project.

The described uncertainties arising from the wrangle between stakeholders are termed as ‘uncertainties of interests’.

Additionally, a project team consisting of various stakeholders can be challenging to coordinate. A lack of clarity in the responsibilities and division of tasks can lead to contradicting or incomplete results and an increasing overall workload. The affiliation of responsibilities to individuals or partiers are furthermore matter to change over time. The described driver is termed as ‘uncertainties of responsibilities’.

Finally, there is a direct influence through the so-called ‘uncertainty of information’. Information can be derived from data, such as the required storage locations for certain load carriers and boundary conditions, such as the available storage surface or legal requirements. In practice, fully integrated databases are rarely available and the collection of data can be challenging. If certain data is not available assumptions are common. Based on the analysis of existing data, predictions must be made in order to obtain the data that are used to serve as basis for the design of the logistics site. Uncertainty in the data, assumptions and predictions add all up on each other, resulting in the overall uncertainty of the planning data. Various boundary conditions such as laws and regulations or strategic management decisions can lead to further uncertainties as the knowledge of the planner on the issues might evolve over time.

The described uncertainties influence the requirements, the objectives and processes of a decision. Therefore, decisions are often neither definite nor optimal. This makes planning difficult. For the planning of large logistic sites various decisions have to be made, on different levels and from different people. Several actions can follow a decision, finally leading to the planning results. The uncertainties subsequently influence the planning results regarding quality, time and costs. Figure 3 is illustrating the described influence of the identified drivers of uncertainty on the planning results.

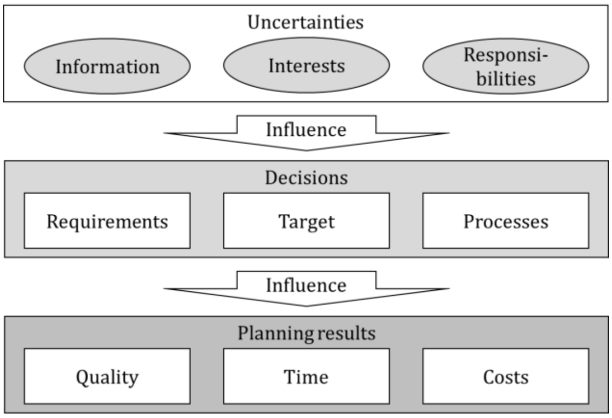

Figure 3: Effects of uncertainties

3.2 Minimizing uncertainties

As previously described, uncertainties in planning increase with the size and complexity of a project. For the planning of large logistic sites, it is therefore particularly important to counteract the uncertainties by applying clear planning methods.

To minimize the uncertainties of interests, good coordination and cooperation between stakeholders is required. Individual planning objectives have to be communicated in an open, transparent and comprehensible way. Clear processes are needed in order to derive common, reliable and consistent planning objectives. The influence of stakeholders in the project needs to be defined by consulting superior managers in order to fundamentally reconcile these determinations with strategic company decisions. The individual planning goals have to be discussed between stakeholders in order to define common goals.

Besides the clear identification of the stakeholders and their responsibilities for decisions and tasks, also tasks and decisions need to be analysed and structured. Overlaps between various decisions and tasks should be avoided. The aim of the decision-/task-structure is to affiliate personal of different fields to support tasks and decisions with their respective competencies. For each individual decision also, a clear decision-making-structure has to be defined and methods applied to increase objectivity. The individual decision-maker need to be defined previously, considering influence of stakeholders on the particular decision and knowledge about the issue.

Significant uncertainties could arise from a lack of information or inaccurate data. Planner are responsible to collect sufficient information to make a certain decision. As described in section 2.1, it is common to carry out an extensive data acquisition before the initialization of a planning project. Since the course of the project is not fully predictable in advance, continuous data acquisition remains necessary during the project. For internal planning data common databases and platforms for communication have to be used to avoid misunderstandings and multiple work. Despite regulations, external information is rarely explicit. Therefore, several internal as well as external knowledge-provider should be consulted in order to build an extensive data pool. Especially, the verification of the data is important as several follow-up decisions and actions depend on them.

3.3 Dealing with uncertainties

Through integration of stakeholders and acquisition of better data, uncertainties in the planning of logistic sites can be minimized but never be fully eliminated. To deal with this issue it is either possible to react to the consequences or to compensate the uncertainties.

Uncertainties can be compensated by applying security margins or introducing redundancy of work. Security margins can be realized by adding extra costs, surfaces, etc. The size of the security margins can be chosen in regard to the estimated uncertainty of the decision. This measure is particularly applicable for the uncertainty of data. To choose reasonable security margins, minimum and maximum values of the planning data can be considered [7].

Redundancy of work is a useful approach if a decision is particularly uncertain. For instance, if two options between which a decision needs to be made are equivalent from a stakeholder point of view. In such cases, several options for the decision can be further investigated. In the course of subsequent planning, each alternative gets further detailed until the primary decision can be made with a sufficient certainty. Up to this point, additional labour has been carried out, but limited project time was wasted in case of a changed decision.

In order to react to uncertainties and the resulting changes of decisions, iteration of planning steps is required. Iteration needs to be possible between different influencing decisions or during a decision-making-process. Every decision-making-process should follow a similar pattern and result in a comprehensible and

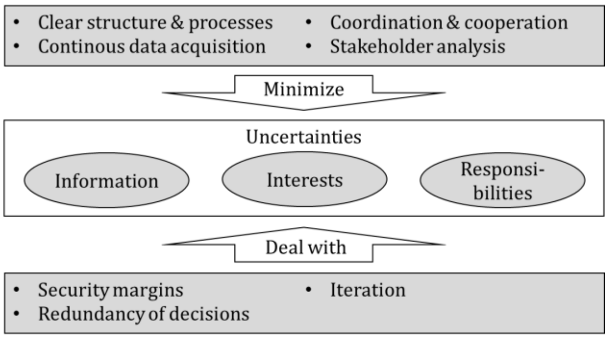

Figure 4: Requirements for planning methods to minimize and deal with uncertainties.

transparent documentation. An approach to realize iteration between influencing decisions is therefore the clear allocation of superordinate and subordinate decisions inside of the previously described top-down decision-structure. In the event that a decision is tipped, all subordinate decisions have to be reconsidered.

Figure 4 summarizes the described measures to reduce the uncertainties in planning. These measures build requirements for the proposed planning framework in order to minimize and deal with uncertainties.

4 PLANNING FRAMEWORK FOR LARGE LOGISTICS SITES

To reduce the risks of uncertainties in planning projects, a new approach is required. A clear identification of stakeholders and planning structures as well as reiterations are highly important. Based on insights from several industrial projects, a planning approach has been developed.

As the analysis of the involved parties, interests and responsibilities is necessary to build common planning objectives, a stakeholder analysis should be the first step of a planning project.

4.1 Stakeholder analysis

The aim of the stakeholder analysis is to create an overview about the involved stakeholders including the project team and external stakeholders [2]. Based on the overview, the technical, economic as well as external interests in terms of sustainable and societal aspects of all parties must be considered for the subsequent definition of planning codex and planning procedure [3].

The members of the project team can be clustered into three main groups according to their role within the planning project (Figure 5). Firstly, the planner are responsible for the conceptual design, processing of planning data and the preparation of decisions within the planning project. The group of planner should be composed cross-functional by members such as internal and external logistics experts, architects and construction experts. Secondly, the knowledge-provider influence the project directly and indirectly by gathering, processing, allocating and provisioning of information on current planning topics. This group consists of internal members such as data analysts and technical experts as well as external members like sales representatives and technical experts of system vendors. The decision-maker are responsible for providing personnel, financial resources and for making a choice for a certain decision alternative. Furthermore, the decision-maker can connect the planner to knowledge-provider and technical experts from different business units. Member of these three groups can be a part of more than one group. For example, planning consultants can be responsible for the actual planning, but they can also contribute their technical expertise as knowledge-provider.

An early and ongoing integration of the decision-maker of the project is crucial for the efficient planning progress and alignment of the potentially different and subjective interests to form a common vision for the future logistics site.

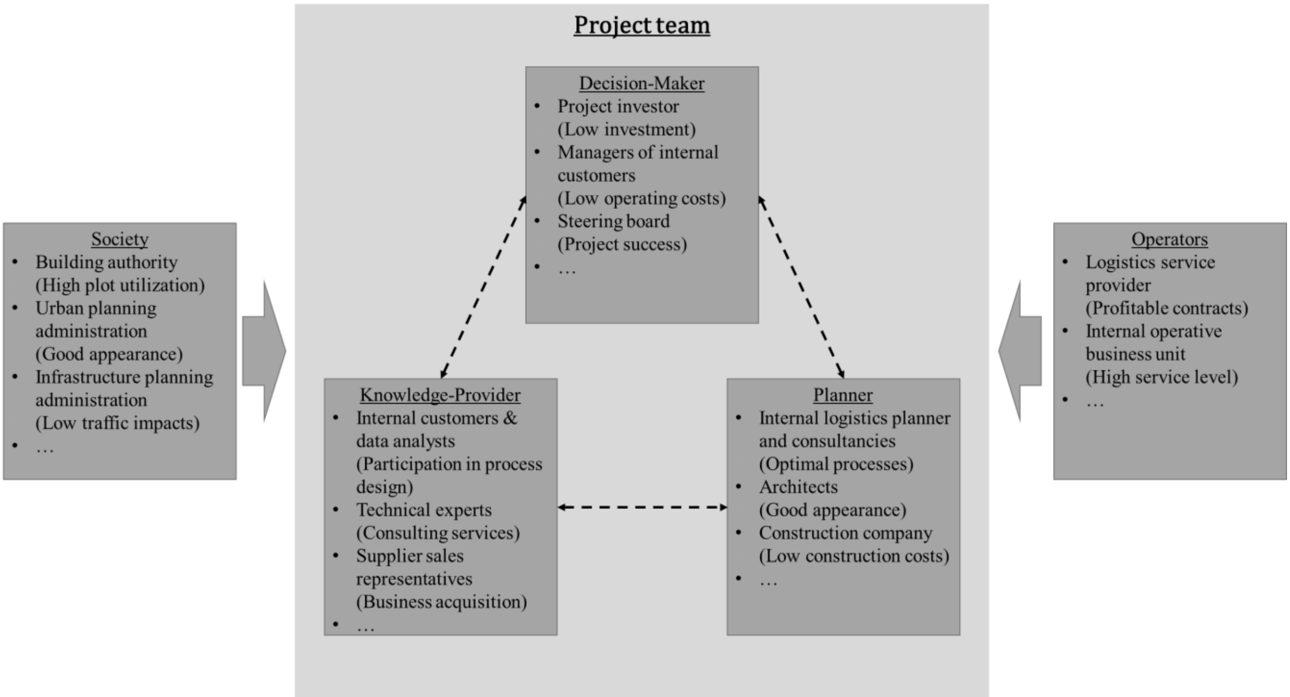

Figure 5: External and internal stakeholder groups and their interests in the planning project

External stakeholders can be clustered into the society and future operators of the logistics site. The interests of the society are mainly represented by regulations, local authorities and administrations, but occasionally also by private initiatives. These actors are primarily concerned about socio-economics and sustainability topics like a high utilization of building plots or a low impact of logistics sites on the traffic situation especially in urban regions [8]. Since the future operation of the logistics site is influenced by all planning decisions, the internal operative business unit or an eventually involved external logistics service provider represent additional stakeholders.

4.2 Definition of the planning codex

After getting a clear view on the stakeholders, their interests and responsibilities, the stakeholders should agree on a corporate planning codex. The planning codex is composed by vision fields and guidelines. The stakeholders who are part of the project team are in charge for defining the vision for the project. Doing so, they are also responsible for taking into account the main interests of external stakeholders such as society's institutions and future site operators next to internal interests. Contradictory interests have to be balanced, resolved or at least decided. The result must be approved by the responsible decision-maker.

The vision should be continuously taken into account for every major decision made during the complete planning process. Moreover, the vision acts as a reminder for the project members in specific situations when planning alternatives or options need to be evaluated. Based on the vision, design guidelines can be derived which later on result in specific measures for the project.

According to Figure 6 the vision definition starts with the vision fields being essential for the representation of all interests within the project team. The vision fields are categories which can still be generic for example like economic benefits or sustainability, because these can be understood as starting points from which more specific guidelines can be derived. At this point of time, these overall principles might be competing, like specific economic benefits and sustainability. Sometimes it may be difficult during the planning phase to combine these aspects without compromises.

Within the next step a set of rules is derived as planning guidelines. These guidelines are object-related, clearly defined and often measurable. For example, these objects can be related to parts of the building structure or used storage technologies. The agreement of all stakeholders and as reliably as possible defined boundary conditions of the project are crucial to ensure the acceptance and usage of the guidelines. Therefore, this combination of steps needs to be performed by all stakeholders which are relevant for the vision definition. The choice of established guidelines should be considered as still mutable in order to act corresponding to these rules but allowing for modifications in order to satisfy new or changed requirements resulting from changes in the data basis or boundary conditions.

The guidelines should be used to determine measures which make the fulfilment of the vision accessible. The

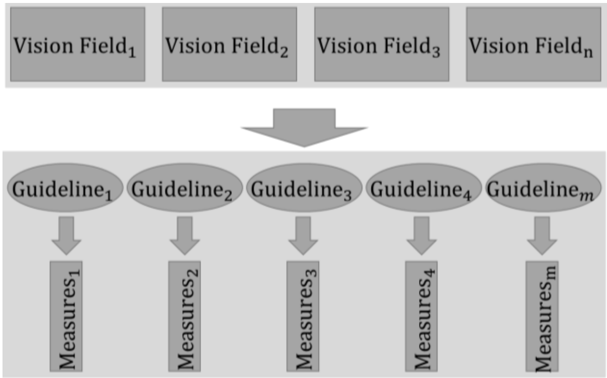

Figure 6: Vision definition process.

measures are formulated by the internal stakeholders. These measures have to be revised in regular intervals, because they are too explicit to be completely determined at the start of the project and in order to work in a flexible way.

4.3 Planning of large logistics sites

In contrast to the recent literature on production and logistics site planning methodologies, the proposed planning procedure is not based on the typical planning stages like project setup, structuring, system design and realization. It is structured like a flexible top-down network of decisions and actions (Figure 7).

In this top-down structure, each decision is followed by actions which lead to decisions on a lower planning level. The decisions on lower levels are determined and derived from decisions on higher levels of the network. In parallel, the influence of a certain decision decreases with the decision level. For example, a possible decision in the beginning of the project could be the proper utilization of the building plot which might lead to a multi-storied logistics site. As a consequence, the storage systems inside the building should also utilize the provided ceiling height. The influence of a certain decision on the entire project decreases with every decision level. But this top-down structure should not be regarded as a barrier for reiteration. For example, higher level decisions can be changed if the data basis of dependent decisions is changing during the planning procedures.

In this structure, the scope of every decision is clearly delimited. This is one more step to minimize uncertainties in the responsibilities, by clearly defined and responsible stakeholders. Therefore, the scope of the decisions on a certain level should not have overlaps with

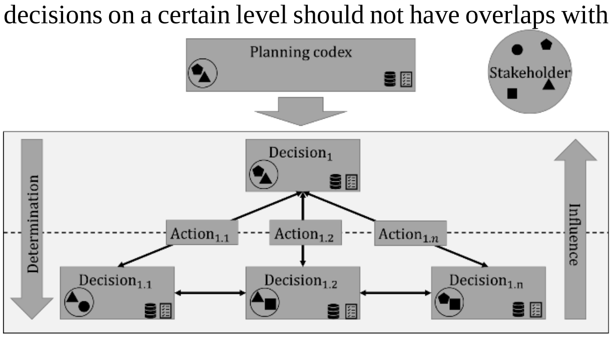

Figure 7: Proposed warehouse planning framework

other decisions on the same level. If a decision in the network shows strong dependencies to other decisions the planning team should consider to merge the mentioned set of decisions to one planning decision. For example, if considerations of the goods receipt processes and storage systems are highly interrelated, a merge of these decisions could be beneficial to combine the competencies of both planning teams and to reduce coordination efforts and interfaces.

4.4 Decision-making steps

Within the presented decision-network, a certain decision is always accompanied by responsible stakeholders and a data basis. The stakeholders are always a subset of the stakeholder pool of the entire project. The database is constantly modified during the course of the project. Every decision must end with a comprehensive documentation for later project demands and overall learnings. The explicit steps in a certain decision of greater importance are illustrated in this section (Figure 8).

The planner have to identify the requirements of the system or object to be designed and to align them to the overall planning codex of the project. On that basis, decision criteria have to be established. Subsequently, possible solutions and scenarios are identified. A morphological box is recommended to build scenarios. According to each process step one or more technical solutions are listed and by the combination of solutions for each step scenarios can be found. This procedure intends to minimize decision biases and ensures a broad decision basis.

During the scenario definition obviously unfeasible technical solutions can be discarded based on decision criteria. From the remaining technical solutions, scenarios will be derived and detailed for further decision-makings. Practical projects have shown a high complexity and time consumption of these steps.

Additionally, during the planning procedures new information can arise, influencing the database of the decision. Thus, planning iterations are essential to include new insights in further concepts and calculations. Therefore, parameterized spreadsheet models are recommended to perform the calculations [1].

The evaluation of the planning options must be carried out in a qualitative and quantitative way to ensure the feasibility and profitability on the one hand and the alignment of the decisions with the planning codex on the other hand. The qualitative evaluation is performed by revised decision criteria to include priorities from later decision stages of the project. These criteria are incorporated into the benefit value analysis. Capacities, investments and recurring costs are investigated by a quantitative evaluation. Finally, the planning team creates a documentation of the decision which presents the decision scope and the proposed solution. Decision-maker can challenge the proposal and select a certain scenario.

In conclusion, the steps of a decision are highly interrelated while the data basis may still change dynamically. Therefore, the participating stakeholders must be open for reiterations and revisions of basic assumptions even in later planning stages. Thus, parameterized spreadsheets are highly recommended. This way of working should create efficient planning procedures even if redundancies in the procedures are unavoidable.

5 EXAMPLARY PLANNING PROJECT

In order to illustrate the proposed planning framework, results from an exemplary planning project are presented. The project deals with the planning of a logistics site, with the strategic purpose to ensure future demands of the production of a large systems manufacturer. Therefore, existing warehouses are consolidated into a new logistics site, which offers reduced operating costs by simplifications of the processes and reduction of surfaces. The new logistics site should be located as close as possible to the actual production site. Hence, the project is located in an urban

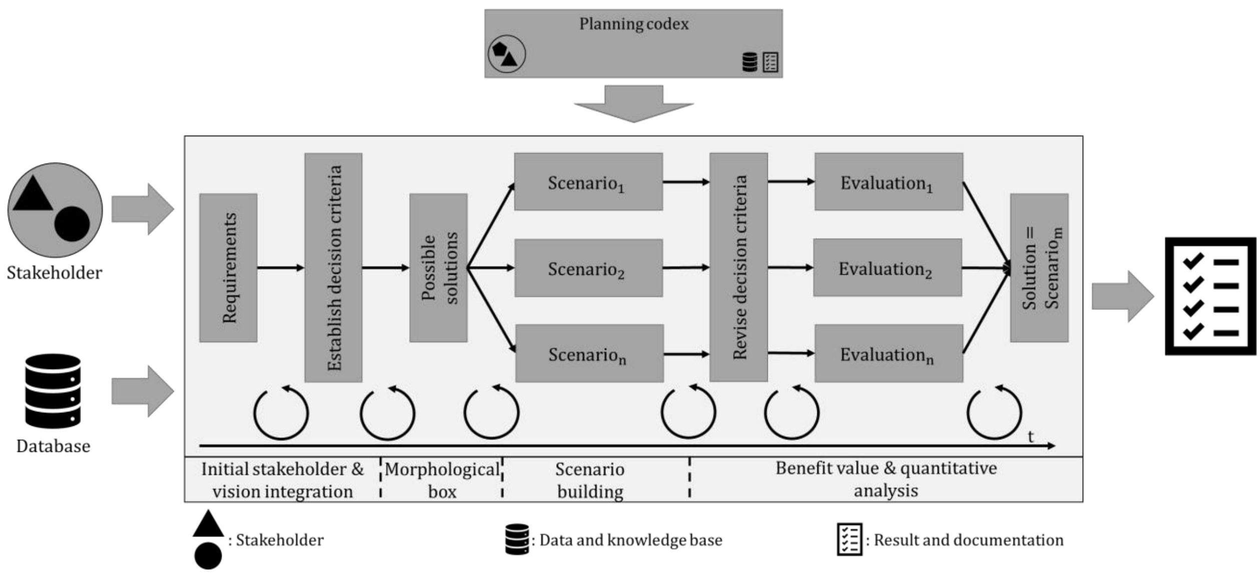

Figure 8: Proposed decision-making steps

environment, leading to the need for an optimal surface utilization avoiding high building plot costs.

5.1 Stakeholder analysis

The core project team consists of some 15 members being responsible for both the design of the building and the planning of the logistics technology. Outside of this core team some 45 stakeholders are identified whose interests have to be considered.

The planner are composed of internal logistics experts from logistics operating and engineering business units. Furthermore, logistics consultants are engaged for the planning of processes, warehouse systems and digital infrastructures. Next to the logistics planner, the construction company is in charge to plan the building of the new logistics site.

These planner are primarily interested in optimal future processes and an overall project success in terms of capital and operating expenditures. Besides this primary interest, internal and external planner may intend to position themselves for future planning and consulting tasks.

Knowledge is provided from over ten stakeholders such as the production, sales representatives of logistics equipment vendors and the current logistics service provider.

The decision-maker are represented by managers with different roles in the corporate organization structure. Thereby, different planning objectives are prevailing within the decision-maker group. The interests of two manager groups have to be integrated. On the one hand, managers who need to bear the subsequent operating expenditures. On the other hand managers being responsible for the project investment who are more concerned about low upfront capital expenditures. Further interests of the society are represented by local authorities which are mainly interested in both an efficient use of land surface and about traffic impact.

The operating logistics service provider of existing logistics sites are mainly integrated as knowledge-provider regarding current material flows and processes.

By the holistic investigation of existing and participating stakeholders inside the planning project the following definition of the planning codex is supported by the comprehensive overview of all interests.

5.2 Vision, guidelines and measures for a large logistics site

For the decision-making in subsequent project phases, interests of some 60 stakeholders need to be included and balanced by the project team. To support the integration, the proposed planning framework recommends the definition of a planning codex. For the actual planning project, this codex is composed out of five vision fields and 13 guidelines which are introduced in the following.

The fields of vision for the planning project address organizational, technological and economic objectives to form a holistic set of rules to align subsequent planning activities with the superordinate planning objectives.

Figure 9 shows two exemplary fields of vision of the project. Economic benefits are mainly generated by the consolidation and reduction of transports, surface requirements and personnel. Furthermore, the use of innovative and adequate technologies can reduce the costs in terms of surface utilization and labour costs. By lean logistics approaches, waste in processes and material demands can be minimized.

The second field of vision for the new logistics site is sustainability in environmental, social and economic

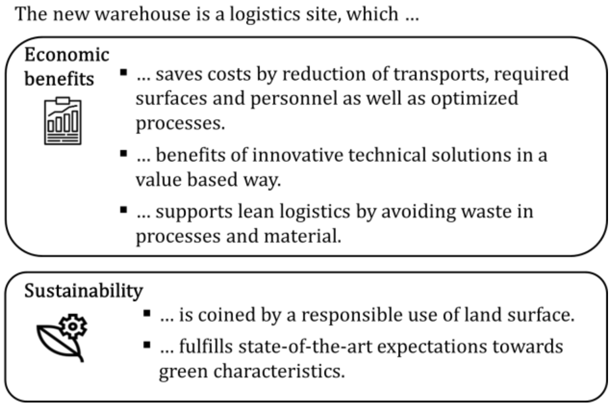

Figure 9: Economic benefits and sustainability as exemplary vision fields

terms. Sustainability especially in terms of building plot utilization is an important topic for logistic projects in urban regions due to expensive and limited building plots for industrial facilities [8]. Further, sustainability must include state-of-the-art technical solutions for green characteristics.

Additional fields of the vision deal with flexible and scalable processes, a good appearance of the logistics facility as well as leadership & human resources focusing on working conditions and responsibilities.

Based on the five vision fields, the project team derives object-related guidelines for certain planning activities. Exemplary guidelines and corresponding measures are given in Table 1. Regarding the building structure, the guidelines could cover the topics high buildings, attractive appearance and extendibility. Potential measures could be to build an at least three-storied logistics facility and to foresee surfaces for future extension. In terms of logistics technologies, potential guidelines could be the usage of innovation and flexible technologies to support a good surface utilization. Furthermore, the separation of value creation and transport leads to dedicated service areas and a specialization of employees responsible for order picking and transport. The installation of mobile shelving racks to reduce aisle surfaces and dedicated service areas for value creating tasks are appropriate measures in terms of logistics technologies.

In investigated industrial projects, the planning codex turned out as an efficient tool for the identification and balancing of the variety of stakeholder interests. Compared to a traditional, extensive requirement specification, the planning code allowed for an earlier identification and documentation of key stakeholder interests. The rather short documentation in the limited number of vision fields and guidelines served as an important basis for further project work. Due to its compact presentation, the fundamental agreement could be quickly recalled in the discussion of later decisions.

Table 1: Derived guidelines and corresponding measures.

Object	Guidelines & measures

Building structure	▪ Rather high than flat
	  ▪ Usage of at least three floors
	  ▪ Efficient usage of the building height with appropriate storage technologies
	▪ Attractive appearance
	  ▪ Different pavements for outside surfaces
	  ▪ Day light on service areas
	▪ Building concept allows extensions
	  ▪ Foresee reserve surface on building plot
	  ▪ Roof & wall openings for later equipment installations

Logistics technologies	▪ Innovative and flexible logistics technologies
	  ▪ Mobile shelving systems
	  ▪ Automated transports
	▪ Separation of value creation and transport
	  ▪ Specific personnel for order picking and transport
	  ▪ Well defined material transfer systems

5.3 Scenario building and decision making

To illustrate the described decision-making steps, in the following the decision process for a storage technology for parts with small volume is described. These are parts which can be stored into boxes with 600mm length and 400mm width.

The decision for the storage technology of these parts was preceded by the decision of the building height determining the maximum system height of the logistics equipment. Furthermore, the macro material flow was specified beforehand. A coequal but not fully independent decision was the decision of logistics equipment for parts of bigger volume.

The knowledge- and database included e.g. the current number of storage locations, the costs per employee, current production rates or existing fire safety regulations. Requirements for the decision, such as the future number of inbound and outbound transports or storage locations were derived from this database.

Important guidelines and measures for the particular decision from the planning codex were for instance the demand for innovative logistic technologies resulting in the requirement for automated transport. The planning codex was furthermore considered to establish first decision criteria and to build a preselection of possible solutions from an initial morphological box.

While the automated solutions Automatic Storage and Retrieval System (ASRS) and AutoStore are particularly appropriate in terms of picking performance, surface utilization, expandability and operating costs, the manual shelving rack results in the lowest investment costs (Figure 10). The carry pick and manual shelving racks solution were discarded due to the lack of advantages in terms of operating costs and surface requirements. The scenarios always included conveying technology and considered the material flow from the put away process tsso picking and consolidation. Shelving racks on three levels with automatic conveyors for material transports, an ASRS and an AutoStore system were selected for detailed considerations.

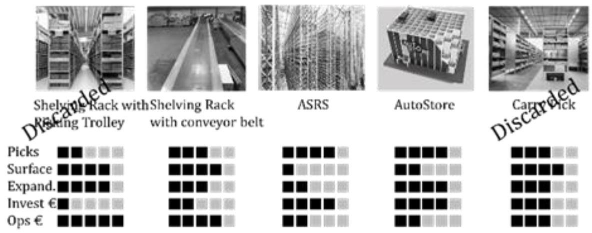

Figure 10: Selected scenarios for further planning

Due to changes in the data base and the requirements for the storage technologies during the planning period, several iterations of the decision-making process became necessary. As a consequence, the AutoStore system was replaced by the scenario storage lifts. Investment costs, operational costs as well as surface requirements were calculated for each scenario. Furthermore, a qualitative analysis was conducted by the project team. Figure 11 shows an abstract of the qualitative evaluation containing three out of ten evaluated criteria. The portfolio diagram from Figure 12 was finally used to compare the scenarios in regard of the total costs for 10 years and their benefit value. As the ASRS shows low total costs and a high benefit it was finally chosen as the preferred solution.

Qualitative evaluation		Scenario 1 - Shelving Rack	Scenario 2 - Storage Lift	Scenario 3 - ASRS Shuttle
Evalution criteria	Weight	Benefit (0-5)	Benefit (0-5)	Benefit (0-5)
Simple increase of storage locations	8%			
Simple increase of pick rate	7%			
Flexibility of pick rate	7%			
…	x%			
Benefit value:	100%	2.1	2.5	3.8

Figure 11: Benefit value analysis

A high number of knowledge-provider were consulted to gather the required information to develop and evaluate the scenarios.

The logistics experts had a strong influence on the decision process for small volume parts, while architects and building experts were hardly involved. Based on a

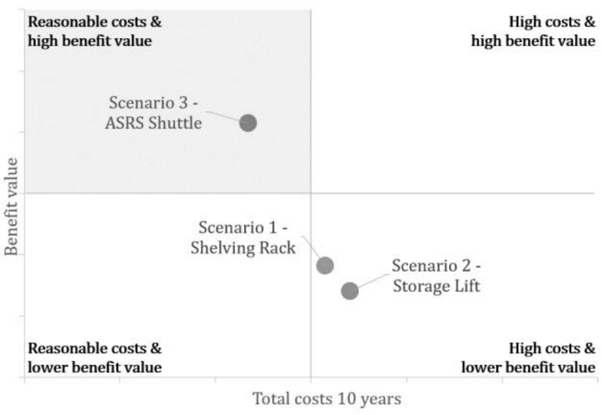

Figure 12: Portfolio diagram of benefit values and total costs

continously updated morphological box and investigated scenarios the decision has finally been made by a group of managers of different departments.

Due to many planning uncertainties a high number of change requests had to be incorporated for a period of 8 months on a weekly basis. The morphological box and a parameterized scenario spreadsheet for the evaluation of competing solutions turned out to be extremely useful during the planning process. Applying these tools, the effects of changes in the planning base could be shown instantly in management meetings and a continuous documentation was maintained.

6 Conclusion

Experiences from several industrial projects showed gaps in the applicability of established methodologies for the planning of production and logistics sites. In such a complex planning project various uncertainties exist, which lead to suboptimal planning results in terms of quality, time and cost. This work presents a planning framework for large logistics sites which was developed based on experiences from industrial projects in order to overcome the identified gaps. The proposed framework includes a comprehensive analysis of the involved stakeholders as well as a planning codex to find common agreements between the stakeholders. In contrast to most planning methodologies, which are structured in a fixed sequence of planning steps, the proposed framework is structured in a network of decisions. This allows a higher flexibility in the planning procedures to react to changing requirements and data. A process for each individual decision is proposed, which includes the creation as well as a quantitative and qualitative evaluation of several planning alternatives. In order to illustrate the developed planning framework, the processes and results from an exemplary planning project are presented.

Overall, the preparation of decisions e. g. the generation of morphological boxes and decision criteria turned out to be highly complex and time consuming in the exemplary project. In addition, the advantages of the method occur only when all stakeholders are well integrated and decisions are not replaced by individual decisions of single stakeholders. Future research should deal with further detailing and validation in order to establish the proposed framework.

The presented work connects academic planning approaches with practical experiences gained in a number of industrial projects. Scientists benefit from this work, as practical limitations and corresponding solutions for academic methodologies are pointed out and insights into practical projects are given. Managers could benefit by introducing the planning framework into their business.

REFERENCES

[1] Baker, P. and Canessa, M.: Warehouse design: A structured approach, European Journal of Operational Research, Vol. 193, No. 2, pp. 425–436, 2009.

[2] Brugha, R. and Varvasovszky, Z.: Stakeholder analysis: a review, Health policy and planning, Vol. 15, No. 3, pp. 239–246, 2000.

[3] Carter, C. R. and Jennings, M. M.: Logistics Social Respomsibility: An Integrative Framework, Journal of Business Logistics, Vol. 23, No. 1, pp. 145–180, 2002.

[4] Gudehus, T.: *Logistik*, Springer Berlin Heidelberg, Berlin, Heidelberg, 2010.

[5] Kettner, H., Schmidt, J., and Greim, H.-R.: *Leitfaden der systematischen Fabrikplanung,* 1984th ed., Hanser, München, 2010.

[6] Martin, H.: *Transport- und Lagerlogistik*, Springer Fachmedien Wiesbaden, Wiesbaden, 2016.

[7] Papadopoulos, C. E. and Yeung, H.: Uncertainty estimation and Monte Carlo simulation method, Flow Measurement and Instrumentation, Vol. 12, No. 4, pp. 291–298, 2001.

[8] C. Raabe: *Logistikmarkt Deutschland.* [Online] Available: https://www.realestate.bnpparibas.de /upload/docs/application/pdf/2019-07/bnppre-immobilien-logistikmarkt-deutschland-at-a-glance-2019q2.pdf?id=p_1743764 (15.08.2019).

[9] ten Hompel, M., Schmidt, T., and Dregger, J.: *Materialflusssysteme*, Springer Berlin Heidelberg, Berlin, Heidelberg, 2018.

[10] Verein Deutscher Ingenieure: *Fabrikplanung*, VDI 5200-1, 2011.

[11] Wiendahl, H.-P., Reichardt, J., and Nyhuis, P.: *Handbuch Fabrikplanung: Konzept, Gestaltung und Umsetzung wandlungsfähiger Produktionsstätten,* 2nd ed., Hanser, München, 2014.