Computer-aided Methods for Operations Planning

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Abstract

In order to enable the use of semi-automatic and automatic operations for production on building sites, operations must be planned in advance and controlled on the basis of the planning.

In a current research project funded by the Federal Republic of Germany, a method is being developed, which supports the computer-aided planning and control of medium-sized building sites. Works on building sites of this size take 4 to 12 months, and they are mostly planned insufficiently. This insufficient planning is due to a lacking support of construction management in the preparation of the building site.

The method is aimed at site managers who manage several medium-sized building sections within one large construction site. Planning of operations and building site facilities is supported as well as economic monitoring via hour and cost control. The required actual data is acquired electronically by the building site staff.

The method incorporates the usual workflow of the site manager and combines the information into few essential characteristic figures.

Keywords: knowledge management, planning of construction projects, economic, workflow

1. Introduction

The German building industry is strongly characterised by medium-sized businesses. Of approx. 76,000 companies in Germany, about 7,700 have between 20 and 200 employees. These companies account for approx. 52% of the € 78 billion annual turnover in the building industry and thus have a very high economic significance in the German construction sector.

On the other hand, companies of this size are often neglected when it comes to improving productivity, because they do not provide enough economic potential to develop their own programmes. Thus, the responsible site managers often still work with old methods for planning and controlling building sites and coordinate the sites insufficiently.

The current research project wants to develop methods in this area which support the working methods of site managers in order to achieve improved profitability.

The analysis of the workflows in companies of this size showed the following deficits:

a. There are no systematic methods for planning and controlling building sites within the organisation. The workflows are often designed too much for building companies with more than 3,000 employees.
b. There are no tools for persons who manage three to five building sites at the same time and generally do not have a group of employees for managing the building site. It is true here, too, that the majority of tools are designed for large construction sites with an individual group of employees for managing the site.

2. Requirements of the Organisation

Building companies with 20 to 200 employees have widely differing structures for the organisation of workflows regarding order processing and for the planning and controlling of the building site. Generally, the organisational structure developed over the years and only rarely was changed systematically but rather adjusted to the day-to-day requirements.

Structures have developed which generally meet the requirements of every-day work. The companies do

see room for improvement; however, they only want improvements to be made if the organisational principle of the respective company does not have to be changed too much.

The workflows in planning and controlling building sites shall be examined. These include the "planning of the building site", the "acquisition of information on the building site" and the "comparison of the planning with the actual operations on the building site" [4],[7], [10].

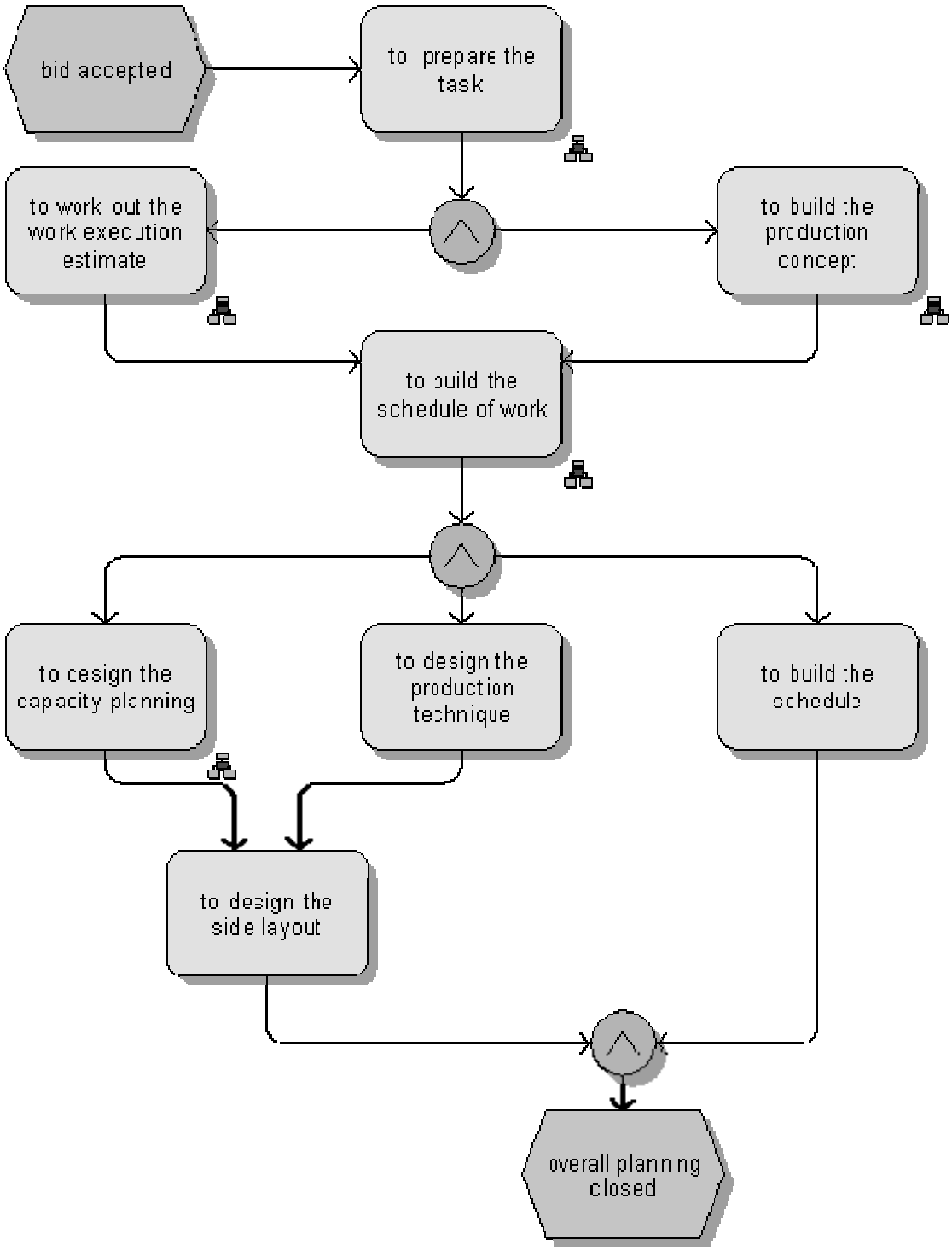

Fig. 1: Basic model "Set up operational planning" as event-driven process chain

3. Systematic Methods

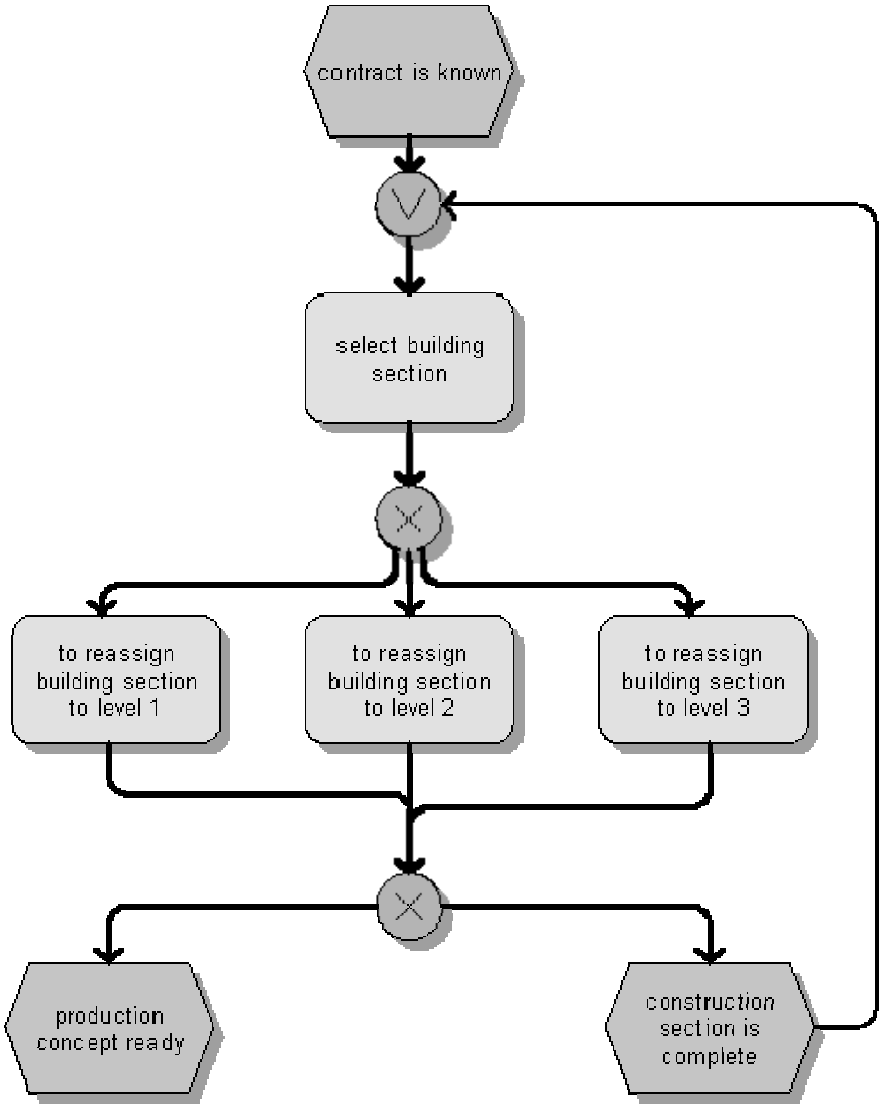

Fig. 2: Model "Set up production concept"

In order to be able to evaluate the various requirements of the companies, a reference model was established first (Fig. 1). This model is the basis, with which the task "Set up operational planning" (Fig. 2) is compared to the organisational structures of the companies. In this comparison, companies of various sizes and order structures are examined.

The reference model is modelled on the basis of "event-driven process chains" (EPC); the current development state of the model can be viewed at the Internet1.

Models on the basis of the EPC [6] consist of four components. The task (function) is symbolised by a green square, the work result (event) by a red hexagon, decisions by a grey circle with the decision characteristics (X) for either/or, (□) for several variants possible and (V) for all variants must be selected. The fourth element is represented by the directional edges, which specify the organisational order.

The individual functions in the basic model are refined by additional models. The refinements are regarded as options. Not all tasks in a refinement are implemented by the companies, only those that are desired.

[1] http://bi-baukom.htw-saarland.de:8080/businesspublisher

However, it is possible to examine the workflow in the company on the basis of the reference model, and weaknesses are shown if provided.

A strongly simplified guideline for smaller building companies has already been developed from the reference model.

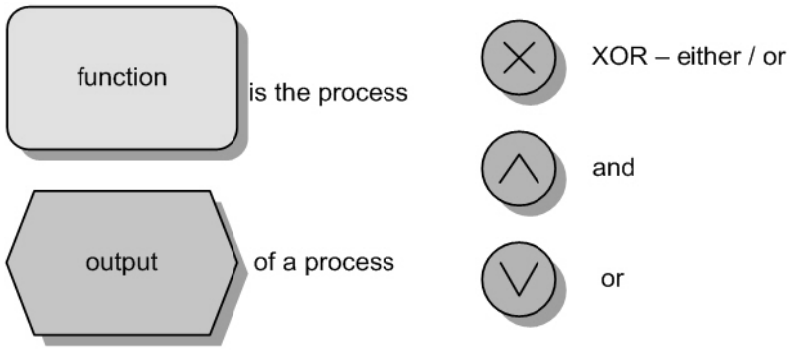

Fig. 3: Model "Set up production concept"

4. Computer-aided Tools

The operational planning of a building site contains the tasks "Planning and preparing the building site" and "Controlling the building site". Both task areas are covered by the site manager responsible and generally without support by additional staff. If it is intended to improve the processing of these task areas and increase the productivity of the building construction in a second step by means of automatic or semi-automatic production facilities, processing must be carried out with the aid of computers. The basis for the development of a computer-aided tool is the reference model, which is provided with detailed instructions and calculations.

The tasks "Generate production concept", "Generate work directory", "Acquire data on building site" and "Short-term income statements" have proven to be critical in the day-to-day implementation of the site manager. Particularly the structure according to which a site manager manages the building site varies a lot and has an impact on all four tasks. If the computer-aided tool is not flexible enough for the implementation of these four tasks, the tool is not used.

4.1 Generating a production concept

In the production concept, the site manager thinks about how to divide the building project into building sections in order to achieve an optimum workflow. The development of a production concept is a creative thought process and must be supported as such by the software and not hindered. The organisation of the building sections, the assignment of sub-sections must be easy to alter. Table calculation programs, for example, are awkward to handle; in contrast, the table structures in word processing programs are very easy to handle. [3]

4.2 Generating a work directory

The work directory collects the services that need to be performed in a building section. Furthermore, the planned revenues and the target hours for the building section are displayed. The work directory thus is an element of the target-performance comparison to be made at a later point.

However, the display of the planned revenues on the basis of the calculation also is the problem when generating a work directory. It is required that all services are recorded and assigned to the building sections. This work cannot be performed by the site manager before construction starts.

Therefore, a method was developed for the work directory with which the revenues per building section can be estimated although only the essential services were recorded. In the course of the building project, the site manager can add the missing services, thus receiving more accurate information on the building section. [5], [8], [2]

4.3 Acquiring data on the building site

In order to be able to compare the planned revenues with the actual costs, the data for the cost calculation

Fig. 4: Design tool production concept

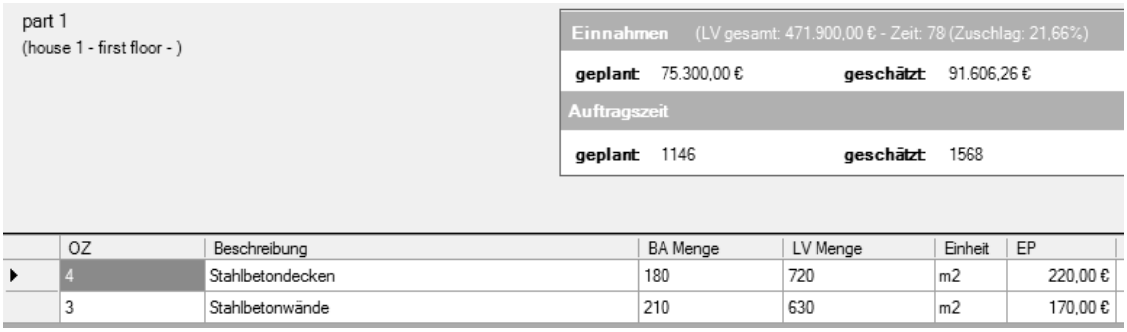

Fig. 5: Work directory

must be acquired on the building site. The data can only be acquired by the building site staff.

However, the quality of the data acquisition relies on the fact that the person acquiring the data knows what the data is being acquired for. This generally is not given on building sites. The foreman has to acquire data, but has nothing to do with their evaluation. Therefore the quality of the data is insufficient.

Thus a procedure was developed by means of which the foreman receives information on the economic situation of the building site. The data is acquired by means of handheld PDAs. The software on the PDA is set up in such a way that first the building section and then the staff working on the building section is recorded. As a result, the foreman only has to acquire the data when he assigns the employees to a new building section. At the same time, the foreman can see the current hours worked on the building section.

Fig. 6: Data acquisition on the PDA

4.4 Short-term income statements

The information on the building section is essential for the site manager for managing a construction site. Experiences can be transferred from one building section to another. The comparison of the planned revenues from the work directory with the actual data from the data acquisition has to be up-to-date and made individually for each building section.

For this, the data from the data acquisition has to be combined into characteristic figures first. The costs of the building site generally consist of costs for wages, material, production facilities and subcontractors. Since the paid working hours are recorded very accurately, the wage costs can be calculated easily; the material costs are the second large area of expenses. However, not all materials can be recorded and calculated in a timely manner. Here, it is necessary to make estimates on the basis of the most important materials. The subcontractor services can be recorded via checked invoices. The production facilities must be estimated by means of comparing the costs with already completed building sites.

building section:	house 1 first floor part 1				
labor cost		1350 h	25,00 €	/h	33.750,00 €
material cost					34.750,00 €
	concrete	120 m3	65,00 €	7.800,00 €	
	steel	80 t	250,00 €	20.000,00 €	
				27.800,00 €	
	loading	25,0%		6.950,00 €	
subcontractor cost					2.500,00 €
equipment cost		6,0%			4.260,00 €
overhead cost		20,0%			15.052,00 €
				expected cost:	90.312,00 €

Fig. 7: Cost structure for a building section

Studies have shown that the estimated costs per building section can achieve an accuracy of 95%. The advantage is the timely evaluation of the building section. Generally, the costs can be calculated one day after the building section has been completed, and the site manager can transfer the results to the next building section.

building section			set income	actual cost	margin
house 1			240.606,00 €	173.312,00 €	- 1.706,00 €
	frist floor		126.606,00 €	90.312,00 €	1.294,00 €
		part 1	91.606,00 €	90.312,00 €	1.294,00 €
		part 2	35.000,00 €		- €
	secound floor		114.000,00 €	83.000,00 €	- 3.000,00 €
		part 2	80.000,00 €	83.000,00 €	- 3.000,00 €
		part 2	34.000,00 €		- €
	third floor		- €	- €	- €
		part 1			- €
		part 2			- €

Fig. 8: Target-performance comparison of the building sections of a building site

In the target-performance comparison, two estimated values are compared on the basis of the finished building section. The revenues to be expected result from the work directory, and the probable costs result from the data acquisition with the corresponding calculation mode. The values are sufficient for evaluating a building section, because particularly the fast acquisition of the characteristic figures and the transfer to other building sections is important here.[3],[9]

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