Detailed Input data Source for Construction Process Simulation

Approach to connect different data source for discrete-event simulation

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Abstract - **Process simulation is an established tool to support planning process. In construction business, process simulation is not gained acceptance for work planning. The reason therefore is the complex development of simulation models because of the lag of comprehensive input data in a suitable form. For meaningful results of process simulation a reliable input data is very important. In construction business scheduling and cost calculation depends in different planning phases on different data source. Developments in object-orientated construction design software offering possibilities to take this information about the object and combine these with process data delivered by dynamic construction data source. This paper presents an approach to integrate the dynamic construction data for input data in a very high level-of-detail. The presented approach is implemented in a discrete-event simulation framework. The objective is a tool for decision support in scheduling and calculation in construction management.**

Keywords-simulation; level-of-detail; process modeling; input data; construction management; scheduling.

I. INTRODUCTION

Modeling and simulation of construction process supports construction planning and can help in reducing the risks concerning budget, time and quality on a construction project [1] [2]. Construction projects are complex because of the need considering different aspects in the planning phase [3]. The client creates a technical specification to define its expectations to the object. These product descriptions define the quality of the product, which has to be built. However, for a detailed job planning it is necessary to know the execution processes in detail. Detailed process chain analyses in construction management are not as well widespread as in stationary industry. Therefore process analysis and description have to done before. In complex process chains with different influences and boundary conditions process simulation is a well established [4]. Process simulation is rarely used for construction process planning because of different aspects. Experts name for the most important impediment for the lacking use of simulation the missing automatically generated input-data [5].

The most important aspect in the development of the methodology is to capture the major requirements that describe the real construction process [6]. This paper presents, how construction processes can be described to deliver valuable entry criteria and input conditions for a simulation model.

This short paper is structured as following: A short summary about the related work in 4D-animation in construction and scheduling with simulation support reproduced in Section II. Following by an explanation about the different planning phases in construction management with different level-of- detail. Section IV explains the two data sources: product data and dynamic construction data. The generated input data will implemented in a discrete-event simulation framework (Section V). Finally we complete with a summary and an outlook for further investigations.

II. LITERATURE REVIEW

A lot of investigations have been done in the area of 4D animation and process simulation. The generation of the input data is crucial according to the many researchers. Huhnt et al. [7] present an approach for data management for animation of construction processes. There modeling approach starts with a decomposition of a building into components. The manufacturing process is described in process-templates and sub-processes. By assigning the building components with the processes a 4D-animation will generate.

In construction projects it is common that drawing, scheduling and estimation are separated planning tasks. Several research projects are initiated to face these challenges. For instance, Kim et al. [8] propose a methodology of developing a 5D system. They link the schedule and costs, which develop in "EVMS" (Earned Value Management System) with the 3D model of a bridge.

Chahrour and Tulke [9] link the 3D model with the time schedule to a 4D Modell. With help of their IFC tool they are able to integrate the process, of time scheduling in a project network. Furthermore they improve a 4D editor and implement their concept to software.

Wu et al. [10] presented a pattern-based approach for facilitating schedule generation and cost analysis in bridge construction projects. Their approach shows a computational method to help project planner to generate the time schedules for bridge automatically. The method has been implemented in a discreet-event simulation environment. They developed a software tool called "Preparator", which assists the scheduler to assign process patterns to individual elements of a 3D building model. The pattern represents a certain construction method including a number of work packages that the user has to decide to apply.

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The presented research projects describe approaches for data management in special fields. On the one hand, the data is used for the visualization and the other for the simulation. The research approach at Bauhaus-University Weimar focus on a data base for input data for simulation. The simulation result can visualized as well. In construction business, process planning is not a static process. Process planning and construction planning will developed dynamically and parallel in different project development phases.

III. LEVEL-OF-DETAIL IN DIFFERENT PLANNING PHASES

Tendering and scheduling in construction management is a progress, which is developed over a large period of time and in different level-of detail [11].

A. *Primilinary planing*

The first phase in the development of a construction project is called "primilinary planning". At the beginning of a project there is only an idea to build an object. There are less information about sizes and quantities. For project managers it is important in this early planning phase on a low level of detail to calculate the costs and construction time in an appropriate way. The figures in this phase are based on experience. For construction projects, they are called *construction cost index* (Baukostenindex-BKI). For different types of buildings the costs per unit are listed.

B. *Tendering*

The "tendering" phase, the construction company calculates the price for the object. The calculation is based on a bill of quantity with a description of the building performance. The bill of quantities defines detail construction quality for all objects. However, there is no virtual connection between processes and objects.

C. *Work planning*

The highest level-of-detail is necessary in the "work planning phase". For robust work planning it is important to know much information about the object and processes as well. The project profit depends a lot on knowledge of the managers and the available tools for decision support.

Our research objective is tool for decision support in construction management. The tool allows what-if-scenarios and a forecast of resource requirements.

The bases for profound decisions are information. All decisions have influences to costs and time. But in the work planning phase the design of the building is almost completed. Therefore it is necessary to get and use more information for decision making in the early planning stage (Fig. 1).

IV. INPUT DATA

Construction business is typically for the one-of-a-kind business. Every building is build at once. Distinguishing features of the unique processes in the construction industry are according to [12]:

- uniqueness of design and construction
- different materials
- resources availability

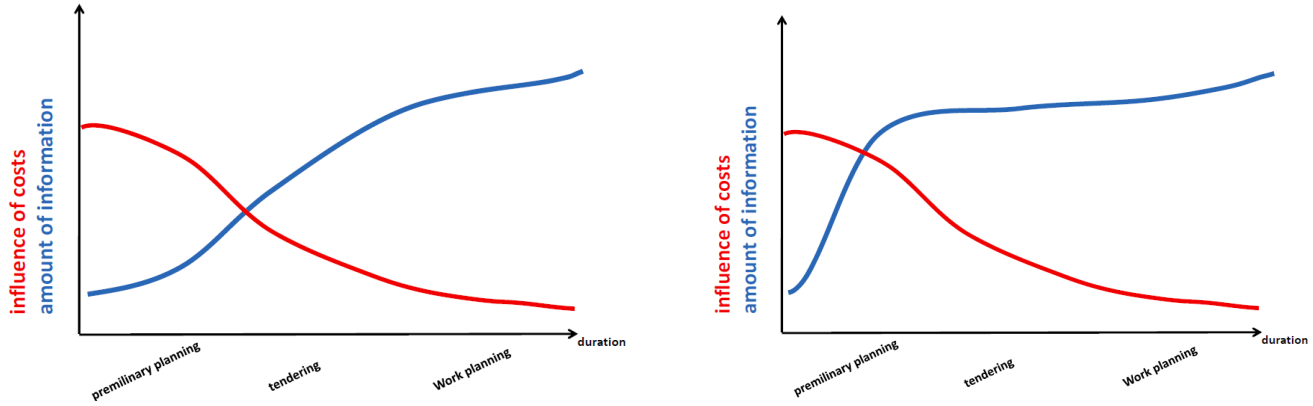

Figure 1. Quantity of information in relation to planning phases; tratitional (left), new apporach (right)

- many disturbances and parameters with stochastic properties
- many different participants
- variety of mandatory and useful dependencies in the processes

Therefore for simulation the construction processes the model, including the input data, has to be created from beginning on. For minimizing the effort for model generation standardized input data is necessary. For Construction simulation there are two main data sources needed. Information about the building including all objects and quantities will import via a Building Information Model (BIM). The construction data with the information about to time, cost, materials and labor recourses will delivered by a specific dynamic data base.

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A. *Product data*

In construction business, 2-dimensional drawings are still usually. New developments in construction software support object-orientated Building Information Models (BIM).

Commercial software programs developed an object orientated modelling environment. The base is different intelligent objects of building types such as walls and windows. These intelligent objects are elements of the product model and can be linked to each other for example that the height of a wall depends on the level of the next ceiling (level). Planning of construction projects in an object orientated environment is helpful for construction management as well as for technical purposes such as clash detection. The objects like walls, columns or decks in an object orientated environment have more information like traditional 3D-Modells. The information is geometrical parameters such as lengths, height, orientation and global coordination. Furthermore, we added information about construction methods on each object. Such as, for constructing a concrete wall you can do this in different ways. The first decision is to build it on site or with prefabricated elements. Such construction relevant information is connected to all objects.

Our research does not replace other researches in the growing field of Building Information Modeling (BIM). It can be considered as a special contribution to additional performances of BIM.

B. *Dynamic construction data*

For more than 40 years a specific data base for construction work planning establish in Germany. The former standardized book of bill of quantities (Standardleistungsbuch-Bau STLB Bau) offering a vast amount of data about construction materials, construction regulations and construction practices [13]. The objective of this approach is the integration of these big data source for discrete-event simulation (Fig. 2).

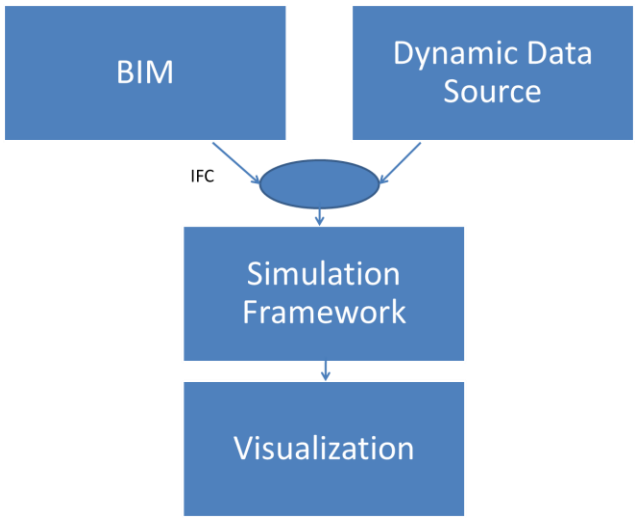

Figure 2. Integration approach

The dynamic construction data base offering a vast amount of structured information of construction processes. The data base structures all construction cost relevant trades. For the simulation studies the process time and costs are required. First each building object has connected with one process from the dynamic data base. The reunite of object and process are implemented in some commercial software as well. But, the process sequences have to create manual. Our approach aims to a definition of constraints in different level-of-detail.

The crucial point for an automatically generated process sequence is correct setting of constraints. This is main development for the simulation framework described in Chapter V. Different planning phases requires different Level-of-Constraints. Therefore we take the existing decomposition of planning phases and define for each level appropriate constraint (Fig. 3).

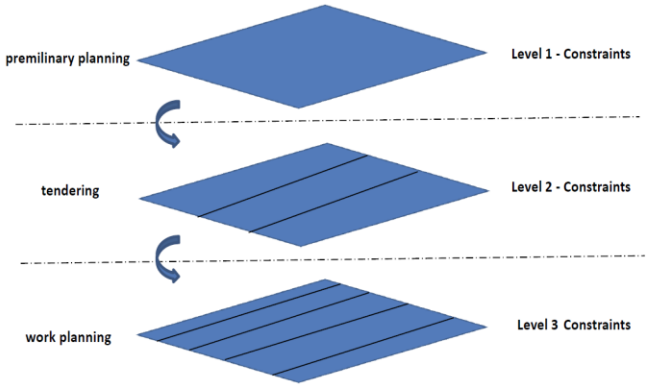

Figure 3. Different level of constraints

V. SIMULATION FRAMEWORK

In this approach, a constraint-based model is used, which has been developed by König et. al. [14] to analyze construction processes. Thereby, the construction tasks and their constraints for production such as technological dependencies, availability and capacity can be specified and valid execution schedules can be generated. The concept has been implemented using discrete-event simulation. That means, only one point of time, at which event occur, are inspected. Within the cooperation SIMoFIT (Simulation of Outfitting Processes in Shipbuilding and Civil Engineering) a constraint-based simulation approach is developed (e.g. [15]). The SIMoFIT cooperation was established between Bauhaus-University Weimar and Flensburger Shipyard, because construction processes in shipbuilding are comparable to building industry [16].

The constraint-based simulation approach is implemented by existing Simulation Toolkit Shipbuilding (STS) and uses the simulation program Plant Simulation provided by SIEMENS PLM. The Flensburger Shipyard and their partners are developing the STS since 2000.

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The researcher group of Bauhaus-University Weimar developed and used the STS components for special aspects in construction management. They developed simulation models to investigate the impact of different influencing parameters on the performance of construction activities.

VI. CONCLUTION AND OUTLOOK

The described approach shows how an existing huge data source can deliver important data for construction simulation. The data source is the base of high level simulation solutions. The level-of-detail these approach depends on the planning phase, which is to consider. Both the building objects as well as the constraints in early planning phase are on a low level-of-detail. The specification during the project development delivers further information. Thus simulation solution develops from rough to detail as well. For that reasons the solutions can help project manager by decision making.

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