SAPP – Simulation aided production planning at Flensburger

SIEMENS

White Paper

Helping shipbuilding planners and shop floor foremen easily analyze and verify all phases of production plans.

Contents

Executive summary

Simulation powerfully supports managing the interaction of product and production flow – especially for the production of complex products in very small series as in shipbuilding. To use the simulation technology Flensburger developed the Simulation Toolkit Shipbuilding (STS) that has enabled the simulation team of Flensburger to effectively and efficiently build up and maintain simulation models of the production. This toolkit is now being further developed and used within an international cooperation of shipyards, universities and institutions called SimCoMar. The simulation is now an integral part of the production planning at Flensburger. The possibility of considering the dynamic relationships between product and production flow results in a reliable plan. Alternate plans can be derived and evaluated very quickly, which leads to basic improvements in the schedule and the needed effort. The impact of disturbances and changes can be shown immediately, and the most cost-effective reaction can be chosen. Finally the communication of the plan to the people who have to work according to it is much easier by simulation. Simulation models have been built with the STS for the different areas of production at Flensburger.Various user interfaces have been developed and implemented for using these models in the different planning phases. Supported by these tools the plan or its variations can be analyzed and verified easily. The SAPP tools are not used by simulation experts, but by the planners and foremen on the shop floor in their daily business.

Introduction

At Flensburger Shipyard (FSG) simulation is well established as the main tool for supporting production decisions. Unlike simulation applications for series production like the automotive industry – which may focus on process design and investment planning – the main focus of using the simulation at Flensburger is continuous production planning.

Basic requirements for using simulation in production planning are the simulation models for the production areas on the one hand and availability of the needed product data on the other hand. In addition to the simulation in investment planning or process engineering, the simulation in production planning must consider the actual situation: the actual production status, the actual design and the actual plan. Therefore several interfaces to the different IT systems of the shipyard had to be developed.

The Simulation Toolkit Shipbuilding

The earlier experiences in simulation at Flensburger showed clearly that for the development and maintenance of such complex and large simulation models as for shipyards a hierarchical and object-oriented modeling approach is more than necessary. Because no such tools were available on the market, Flensburger's simulation team developed its own simulation toolset called the Simulation Toolkit Shipbuilding (STS). This toolkit contains the whole variety of simulation functions needed for modeling production of a shipyard or its suppliers. The STS is programmed for independent shipyard application. The tools can be easily implemented in all kinds of simulation models. They can be adapted to specific tasks by adjusting their parameters.

Because the STS can be used universally and to expedite development of shipbuilding simulation, an international cooperation community has been established consisting of shipyards, universities and institutions called SimCoMar (Simulation Cooperation in the Maritime Industries). At present, the cooperation partners are Flensburger Shipyard, Nordseewerke Emden, the Technical Universities of Hamburg-Harburg and Delft and the Center of Maritime Technologies (CMT). The goal of this cooperation is further development of the STS, knowledge exchange in applying simulation and joint research (Figure I). SimCoMar as the community of STS users is open for new development partners as well as for other shipyards or suppliers that just want to use the simulation in investment or production planning.

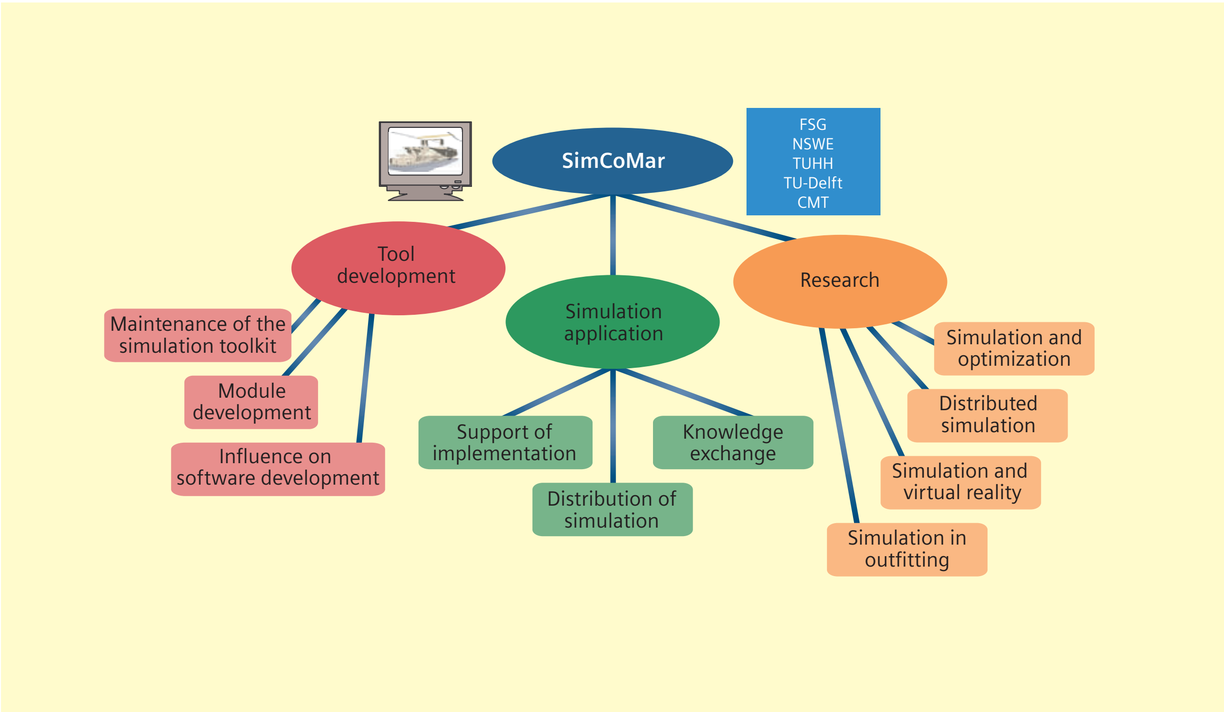

Figure I: Goals and tasks for SimCoMar.

SAPP – Simulation aided production planning

Simulation aided production planning (SAPP) integrates the simulation technology into all phases of the planning process (Figure 2). In the strategic planning phase the production program for a ship is defined based on the early design. The tactical planning leads to detailing the plan and adjusting resources according to the actual production status. In operative control, the foreman on the shop floor realizes the plan and reacts to possible disturbances like lost material or machine breakdowns.

Simulation is not a substitution for planning but should work as an integral part of the planning process. The plan can be substantially evaluated in all planning phases, always based on the actual data from design and production. This increases not only quality and flexibility but also reliability of the plan.

There are various advantages of SAPP. Evaluation of the plan can be done considering all dynamic interactions between the product and production (Figure 3). Alternative plans can be generated and evaluated quickly so the most cost-efficient plan can be determined. Another advantage is improvement in communicating the plan. The planner can show the foreman or worker the planning results and the impact on production flow using the simulation output. Animations can play an important role in this regard. Because simulation models should be validated and committed by production management before they are used, the simulation works as an objective decision-based tool. This helps avoid discussions that are not motivated by technical problems. SAPP dramatically increases planning flexibility. The simulation is linked to the actual design and production situation. Therefore the plan can be adapted to changes in the product or in the production situation easily and the impact of these changes can be evaluated quickly.

Figure 2: The phases of production planning.

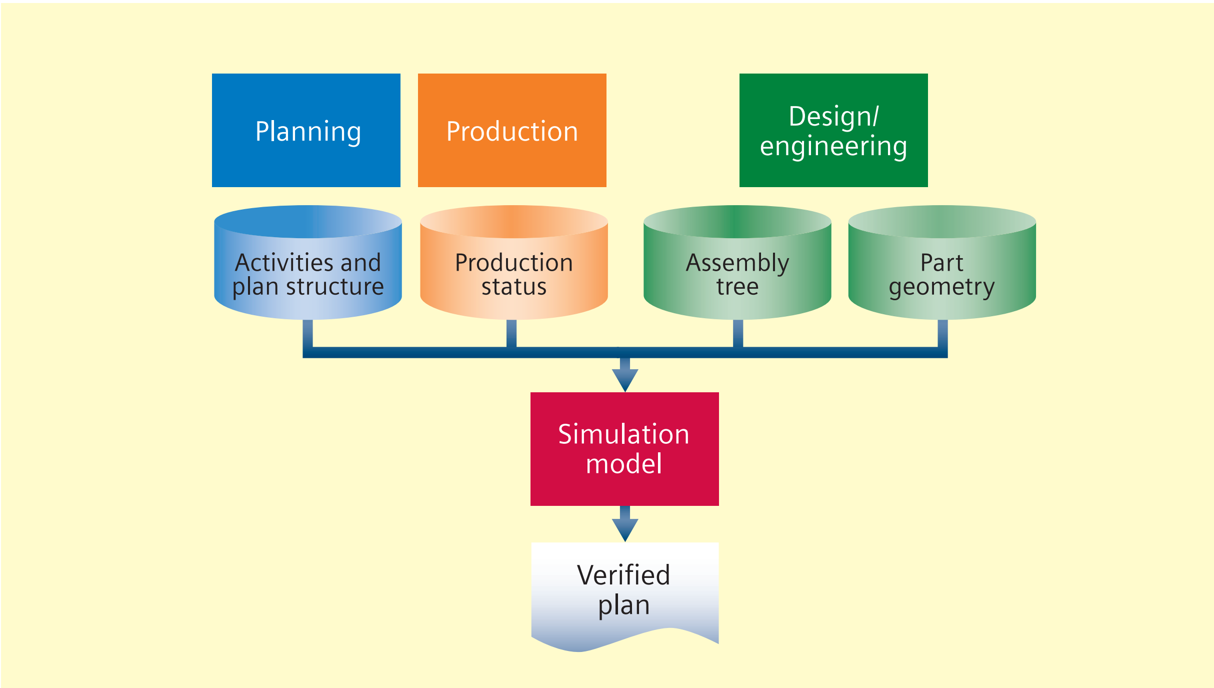

Figure 3: Data flow for SAPP.

The earlier the simulation is to be used in the planning process, the more uncertain the product data gets. In the early phases, part descriptions are unavailable, and the assembly tree is not yet determined in detail. Therefore an internal project called "DigiMeth" was started two years ago at Flensburger to semi-automatically generate an assembly tree using all the existing part information at anytime during the design process. SAPP also means the use of simulation not only by experts, but by every planner involved. Therefore application-specific user interfaces must be developed for presenting the simulation input, changing the parameters and showing results of the simulation runs.

Of course, simulation cannot prevent disturbances completely. Machines still break down, material is lost or workers get sick. But these disturbances can easily be considered in the simulation model as a basis for the next simulation runs. Therefore the impact of disturbances can be evaluated quickly and thoroughly by SAPP.

SAAP applications at Flensburger

Following the modeling process at Flensburger, several applications for SAPP have been developed for the different production areas (Figure 4). These applications are standardized and implemented in a software environment called the simulation database. The single applications are used separately within tactical and operative planning and can be combined for strategic or holistic analyses. Planners and foremen on the shop floor use the applications. Therefore, not only the planners but also every involved foreman received training in the basic simulation software and the STS to provide them fundamental knowledge about simulation and its handling. This training created a much better acceptance of simulation in the planning offices and on the shop floor.

In part fabrication, detailed machine planning is based on simulation. Two applications are implemented – one for profile fabrication and the other one for plate fabrication – by cutting machines and manual workplaces. The main goal is to assure sufficient delivery dates for the parts in the assembly stations with minimum cost. Figure 5 shows delivery reliability of the profile fabrication as a result of a simulation run. Critical buffer sizes can be detected as well as oversized buffers. The results are used to adjust the sequences in order to achieve constantly low but sufficient buffer sizes for the assembly date.

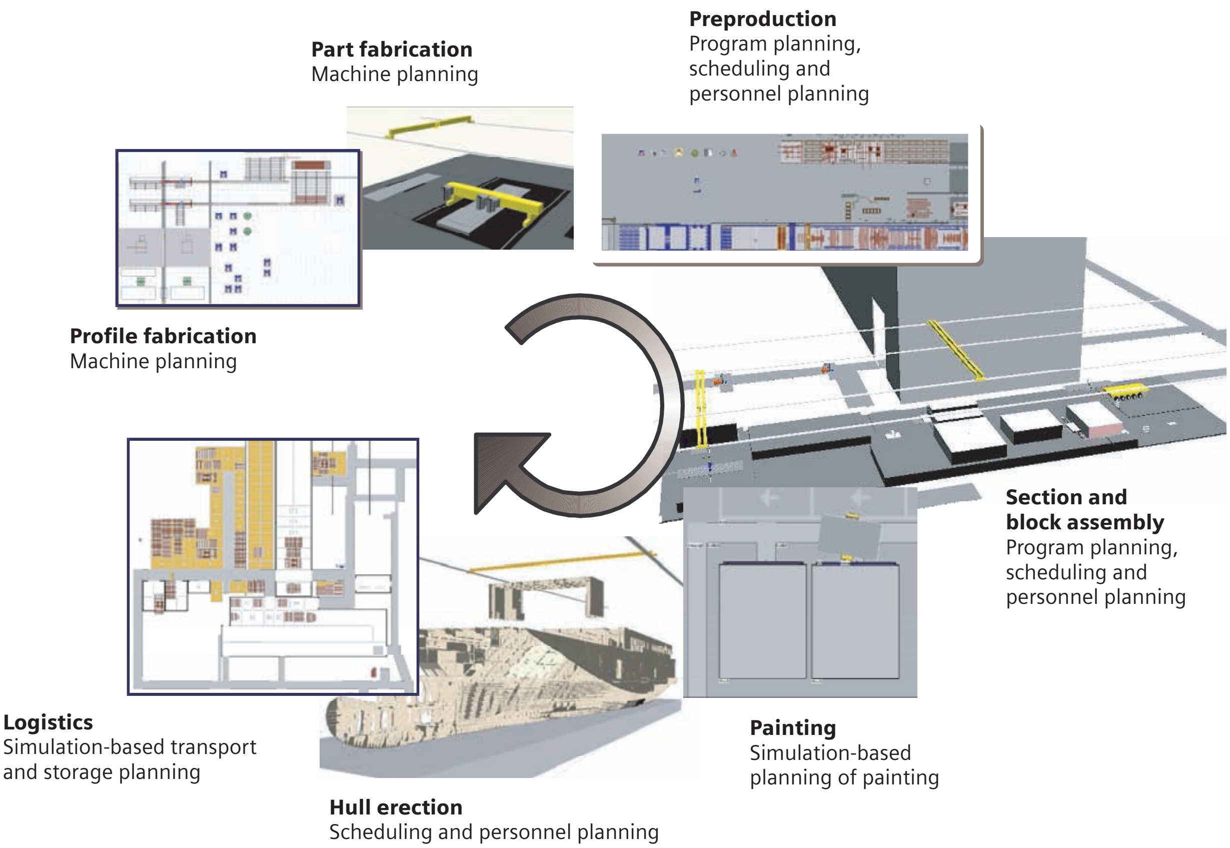

Figure 4: SAPP applications at Flensburger.

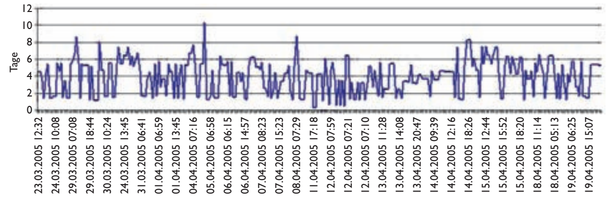

Figure 5: Simulation output: buffer to assembly indicates delivery reliability of profile fabrication.

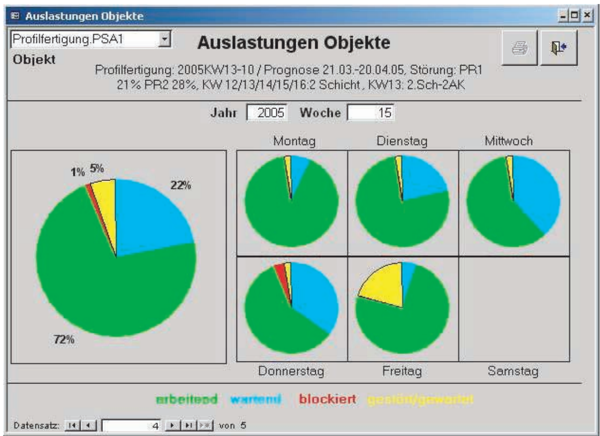

Figure 6: Simulation output: utilization ratios per day and week for a profile robot.

To avoid critical buffer sizes, the utilization diagrams are analyzed (Figure 6). If there are periods of low workload, the production program can be shifted. By analyzing the utilization diagrams, the sufficient resource allocation can be defined as well.

After the planner has determined the simulation results as satisfactory, the simulated production dates are transferred to the material control system MARS. Using these production dates, MARS automatically sorts trailers for the appropriate raw material provision and transfers this information to the supplier.

The preproduction and especially the panel line and section assembly was the first SAPP application at Flensburger. Planning and control in this area have been simulation-aided since February 2002. In the early planning phase, sequences and dates are determined as a result of various simulation runs. The manning level is adjusted weekly considering the actual situation in production. The amount of workers with the needed qualifications is determined after several simulation runs every week. The latest development in preproduction is the simulation of subassembly production. Models for these areas were built up and validated. Presently tests are carried out to implement the model into the planning process. The goal is similar to the applications in part production: assure delivery of the subassemblies and components on time to production stations, such as section assembly while using a minimum effort. The first trials have shown that personnel can be reduced after stabilizing the manning levels by adjusting production dates.

In section and block assembly, simulation is in the validating and implementing phase. The modeling of these areas was more challenging because not only the space allocation had to be considered but also the variety of different assembling procedures. Concerning the modeling of assembly processes, the "assembly control simulation tool" was developed and implemented into the STS and is now flexibly used in all assembly areas of the shipyard. It controls multiple parallel assembling processes while considering their individual strategy and characteristics (Figure 7).

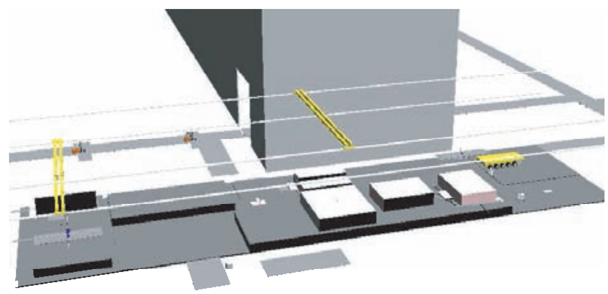

Figure 7: Simulation model of section and block assembly considering space allocation.

An important SAPP application is the painting hall planning tool (Figure 8) because the two painting halls are one of the bottlenecks in Flensburger's production. In an early planning phase the allocation of the painting halls is simulated considering:

- Available space and block geometry
- Individual painting requirements of each block
- Assembly date of block
- Environmental constraints, for example delays for shot-blasting to reduce emissions
- Seasonal weather influences

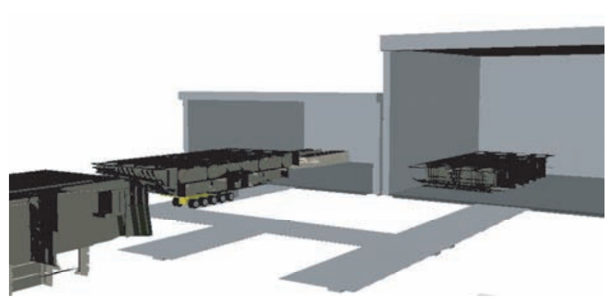

Figure 8: Simulation model of the painting halls.

The simulation considers the actual production situation, requirements of the production steps – mainly hull erection – and special presettings of the planner. On this basis the simulation model automatically defines the future allocation of the painting halls. The simulation database provides the painting plan consisting of the painting dates in table form per hall, utilization charts for each painting hall and pictures of every single allocation period. The latter is shown in Figure 9 as two blocks and two outfitting parts in one of the halls added by the list of blocks that will await painting at that certain time.

Figure 9: Screenshots of the painting hall allocation as part of the painting plan.

The simulation model of the hull erection (Figure 10) contains all the steel work done on the slipway at this stage of development. The interactions with the outfitting processes are considered only in principle. At present the model is being validated to enable the use within SAPP. The main focus using this application will be the balance of the worker's utilization.

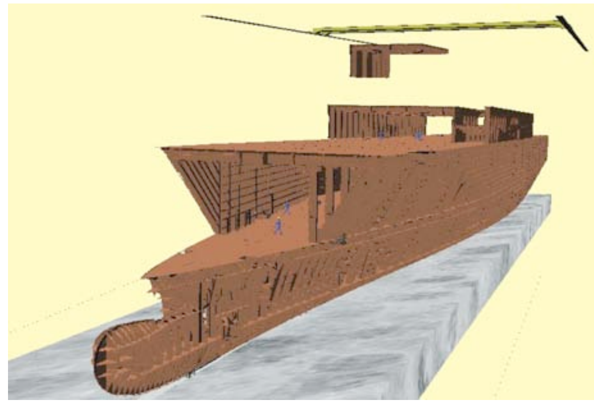

Figure I0: Simulation model of erecting the hull on the slipway.

The simulation model of the internal logistics at Flensburger works as the connection of the production areas. It also contains the different storage areas with their specifics like crane accessibility.

Especially on a compact shipyard like Flensburger, space for storing blocks is a limited resource. Around the launching respectively keel-laying date a large number of blocks has been produced and awaits assembly on the slipway. Therefore the simulation is used to determine the sufficient space allocation in the storage areas considering special storage requirements for necessary outfitting work. Considering the actual situation in the production and storage areas, simulation of the logistics also provides the transport plan for the heavy constructions automatically. Transport lists can be generated for each of the transportation means with date and time of transport, the block to be transferred and the places where it should be picked up and delivered to. Especially the transport chains of different transportation means, like cranes and heavy-weight transporters, can be determined much easier this way.

Results of using SAPP

Flensburger Shipyard has benefited in many ways from the implementation of SAPP. Planning reliability has been achieved. In the simulated stations there are no delays any more that are not detected and tolerated for other reasons. Continuous validation of the simulation models assures that changes in production methods are considered as soon as possible. Using SAPP can also decrease production costs. While implementing SAPP in preproduction, the manning level on the panel line can be decreased by more than 30 percent. In strategic program planning for new ships, the work determining the sequences stabilizes load for the production stations. The schedule is derived directly from the simulation. Another interesting result is that the impact of product changes can be drastically decreased. A new type of ship is now produced in the simulation long before the first real steel cut. The impact of the new ship on production flow is evaluated in the computer. Bottlenecks are detected early enough to avoid unwanted consequences. Positive series effects can be achieved, producing the first ship on schedule.

Outlook

The next step in SAPP will be completion of the simulation model to realize the virtual shipyard. In steel production including pre-outfitting this will mainly be a matter of validating and implementing the existing models. Regarding final outfitting, the basic functionalities recently developed in a research program funded by the Federal Ministry of Education and Research have to be implemented in the STS. Also the acquisition and structuring of outfitting data must be worked on in the future. Combined with the early product data from the DigiMeth tool, the virtual shipyard will be part of the early planning phase and determination of the production program for a new ship. The most cost-efficient way of producing that ship will then be simulated in the context of the whole shipyard including outfitting processes. The present use of simulation in production planning is more time-consuming than it should be. To improve the plan, many simulation runs are often needed to find a sufficient solution. But an optimization tool could control the varying of parameters for simulation runs. Therefore the linking of simulation and optimization tools will be one of the major developments in the future.

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