The Simulation Toolkit Shipbuilding (STS) – 10 Years of Cooperative Development and Interbranch Applications

Dirk Steinhauer, Flensburger Schiffbau-Gesellschaft mbH & Co. KG,
Flensburg/Germany, steinhauer@fsg-ship.de

Abstract

At Flensburger Shipyard simulation has been established as the main tool to support the decisions in production facility planning as well as in production planning and control. Because the available simulation tools are not sufficient for the usage in shipbuilding Flensburger Shipyard started the development of the Simulation Toolkit Shipbuilding (STS) in the year 2000. The STS contains a large variety of simulation tools for material flow modelling, model management, execution strategies and output analysis not strongly related to shipbuilding any more. It is further developed and used within the international cooperation SimCoMar and in the interbranch cooperation SIMoFIT.

1. Introduction

Especially in shipbuilding as a one-off-a-kind production the minimization of resources and the reliable adherence to a tight schedule is challenging. The dynamic dependencies between the product with its internal diversity of elements, the production processes and the involved resources are just too complex. Therefore there is a special necessity in a one-off-a-kind production for tools to manage the dynamic relationships. Simulation technology has been successfully used and integrated at shipyards for these purposes.

Since about 1997 Flensburger Shipyard has been working intensively on simulation in production and logistics. In the beginning facility layouts were evaluated by simulation to support several investment projects. After the successful application in these projects simulation was integrated into the production planning and control, *Steinhauer (2005)*. One of the most important aspects of using simulation in production planning is the increase of planning reliability and robustness as well as the minimization of risks. Because the major impacts on the production by the product, the building method or other constraints can be analyzed dynamically, possible bottlenecks are detected and avoided in advance. The plan can be verified and optimized by building the ship virtually in the computer before building it in the real shipyard.

The success of the first simulation projects and the potentials that became apparent resulted in a more general simulation strategy at Flensburger Shipyard by the end of the 1990s. Due to the experiences that had been gained with the simulation tools used at that time a change of the software and the modelling philosophy became necessary. The effort for building up and maintaining the simulation models had been too high.

Building simulation models of production processes can be done efficiently using predefined object libraries. But the available simulation tools are not sufficient for the usage in shipbuilding since the development of these tools was primarily initiated and driven by the automotive industries. For these or comparable industries libraries of simulation tools are available. The demands of the shipbuilding industries could not be met by those libraries. The main reason was their focus on line oriented production processes compared to the site production typically used in shipbuilding. Furthermore the work packages to be managed in shipbuilding are a lot more complex.

At Flensburger shipyard the development of a library of reusable simulation tools for shipbuilding procedures started in the year 2000. The Simulation Toolkit Shipbuilding (STS) is based on the simulation software Plant Simulation by Siemens PLM, formerly known as Simple++ or eM-Plant by AESOP respectively Tecnomatix. Plant Simulation as an object oriented simulation software provides the functionality for programming and administrating reusable simulation modules.

STS contains a large variety of simulation tools for material flow modelling, model management, execution strategies, data input and output analysis. In the meantime only few tools are still strongly related to shipbuilding production respectively to steel fabrication aspects. Most of the tools provide a more general functionality for fabrication, assembly and logistics usable in many industries having comparable production conditions to shipbuilding.

Today, STS is the backbone of the simulation work at Flensburger shipyard as well as in other companies, universities and research institutes not only related to shipbuilding but also to other industries like the building industry. Modelling expertise from different branches and application scenarios meets in STS and furthers the development of its tools.

2. Philosophy of STS

The prior intention of STS is to enable the user to build up simulation models of production procedures in shipbuilding or a comparable industry in a most efficient and effective way. The effort for the modelling process shall be minimized by providing resusable simulation tools to be combined to a simulation model for the special purpose. Not only the installation of the pure functionality, but also the model building process and the operation of the model shall be supported. Therefore a set of administrating tools is additionally included providing support in structuring and organizing the model. For several typical application cases model patterns are available to be inserted and adjusted to the special requirements.

Soon after starting to use the simulation in shipbuilding it became obvious that the individual adjustability of simulation models is of major importance. Not any shipyard strictly follows a standard routine in running its production flow. Special adaptions are very common due to the special ship types to be built, special restrictions of the shipyard or even special habits of the operating staff. Therefore an important aspect of STS philosophy is to provide interfaces for user defined rules and specific settings.

Another aspect of STS' philosophy is the cooperative development. The simulation team at Flensburger shipyard would not be able to build up, maintain and develop such a software package with sufficient power on its own. Therefore cooperation communities where founded to develop the tools and to organize the application. Requirements for further development from application cases in different industries are coordinated and integrated to bring up general solutions for the simulation challenges.

The first cooperation founded in the field of simulation was the Simulation Cooperation in the Maritime Industries (SimCoMar, www.simcomar.com) bringing together shipyards, universities and a research institute. SimCoMar has become the maritime forum for the joint development of new or existing simulation tools, for mutual support in implementation of simulation technology and for initiating research and development in the field of simulation.

In 2006 SIMoFIT (Simulation of Outfitting in Shipbuilding and Civil Engineering, www.simofit.com) was founded as an interbranch cooperation between shipbuilding and civil engineering *Steinhauer (2007)*. Flensburger Shipyard, the Bauhaus-University Weimar, the Ruhr-University Bochum and SimPlan AG as a simulation consultancy join this cooperation. Outfitting processes in shipbuilding and building industry bear a high resemblance to each other. The same restrictions have to be considered such as dependencies between outfitting tasks, availability of resources and required work spaces as well as changing transport ways. In addition the planners have to answer the same questions: how to find a practicable schedule with sufficiently utilized equipment and employees satisfying principal guidelines. In the interbranch team of SIMoFIT methods for outfitting simulation are further developed and used in various fields. One of the major steps forward was the adaption of the constraint satisfaction method to the simulation. Complex dependencies in the production flow can now be modelled and considered in the simulation.

Another aspect of the STS' philosophy is the integration of well-proven modelling approaches for a multitude of different production scenarios. Not least, the less experienced simulation user is supported in the work of designing and building a simulation model.

3. Model building using STS

Using STS two basic modelling approaches can be chosen which are different but not mutually exclusive:

- The first approach is a more abstract definition of processes, their constraints and the required resources on any level of detail. For this definition a generic method was developed in order to minimize the effort for process and constraint definition. As part of this method process patterns can be defined including their typical process constraints. Global constraints can be generated from definitions on different levels of abstraction. This simulation approach enables the user e.g. to build up simulation models of flexible assembly processes for outfitting of ships or constructing of a building.

- Following the second approach the modelling is geared by the production facilities to be modelled. Tools for the single machines, production facilities or transport means are inserted and linked along the material flow by logistic functions.

In many applications both approaches are used and merged because a flexible definition of processes is as important as the consideration of the definite production environment e.g. in a production hall.

There is a strong communication on different levels between the tools of STS. Software design patterns like the observer pattern are implemented for managing the communication. Therefore information about the collaborating tools is available where it is required when building up the model and during the simulation run, e.g.

- the available qualifications of the personnel are listed when the required resources for running a machine are selected or

- the crane transport from one station to another is automatically calculated and performed based on the positions of the stations and their loading or discharging specifics.

When having inserted a simulation tool of STS or when building up a model there is a variety of possibilities to implement user defined rules or processes. STS tools e.g. provide interfaces to user definable controls which can be programmed in Plant Simulation's own programming language SimTalk. The specific rules or restrictions e.g. for space allocation, resource selection or a special transport way can be implemented into the model in this way.

3.1 Update functionalities

Due to the experiences Flensburger's simulation team gained with other simulation tools before using Plant Simulation the first functionality to be developed was an update procedure. Existing simulation models using STS tools can be updated to the latest version of STS not losing their parameterization. New functions of existing tools or new simulation tools are available in the simulation model afterwards.

STS is administrated at Flensburger Shipyard. New functions in existing tools or new tools developed by partners are integrated and published in Flensburg. New versions or servicepacks of STS can be downloaded from the STS homepage.

3.2 3D Animation

The animation of simulation models became of more interest when the processes to be modelled became more complex. The animation helps a lot in verifying the model and in communicating it with the staff on the shop floor. Besides of that 3D animation can be of help in addition to the technical results when investment decisions have to be made.

In order to minimise the effort for the user to create a 3D animation of the model a special approach has been developed and implemented into STS. The simulation tools of STS contain 3D information and functionality which can be used as default or user defined. After building a simulation model using STS, the 3D animation can be generated by using the simulation tool STS_ModelGenerator3D. By a mouse click a method is executed and the 3D model is generated fully automatically, Fig. 1.

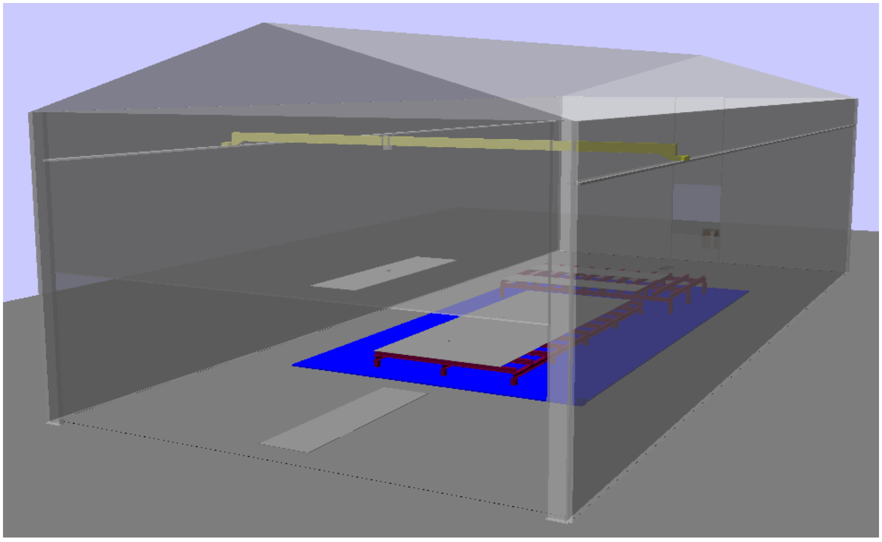

Fig. 1: 3D animation of an example model

Additional functionality to improve the 3D scene from a more visual then technical point of view is provided in STS as well:

- the tool STS_HallGenerator to create buildings in the 3D model
- interpolation function for easy definition of paths for camera flights
- methods for the creation of user defined geometry
- import functionality for 3D geometry from CAD

4. Simulation tools of STS

The STS tools are structured by their typical fields of application, Fig. 2. Tools of a general functionality and administrational tools are grouped as “Basics”. This group of tools contains amonst many others the administrational tools, the statistic functions, the personnel control, the space tool and the interface to the optimizing software ISSOP which can be integrated into the simulation model to do simulation based optimization.

All types of facilities and process functions related to steel fabrications form the group “Steel”. Likewise the groups “Transport”, “Logistics”, “Material” and “Interior fitting” contain related tools. Objects for the modelling of “Outfitting” procedures were being integrated based on the results of the Simba research project (simulation object library for ship’s outfitting procedures) that was funded by the German ministry for education and research, *Steinhauer et al. (2005).* Fig. 3 shows a selection of simulation tools of STS.

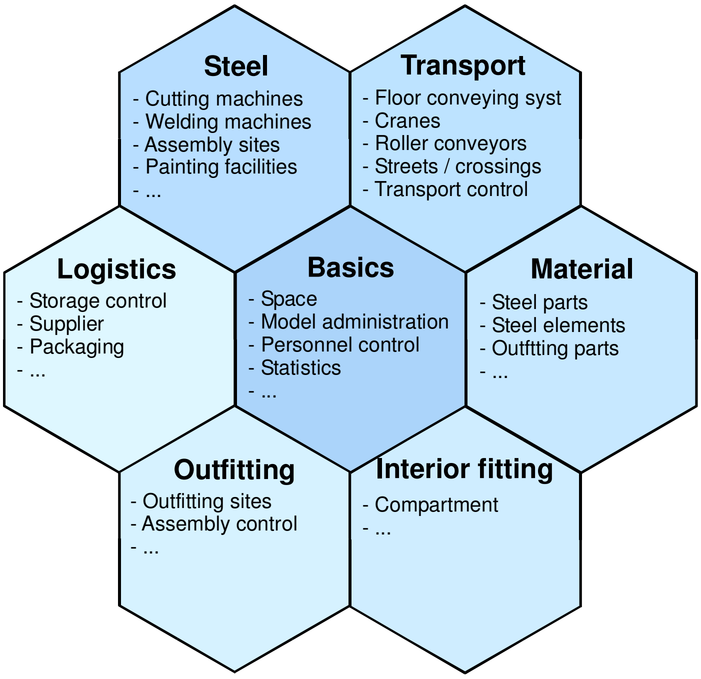

Fig.2: Structure of STS general functions

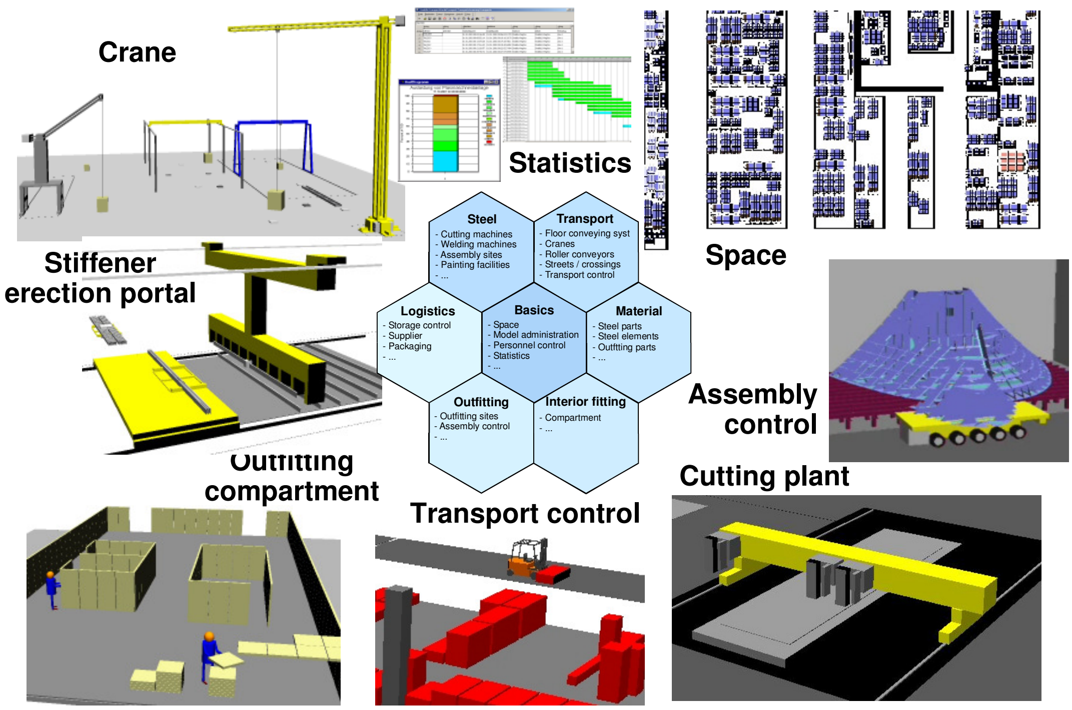

Fig.3: Selection of simulation tools of the STS

4.1 The administration tool (STS_Administration)

The general administration of the STS is done by using the tool STS_Administration which is the first to be inserted into the simulation model. The main functionality of this tool is to manage the loading respectively the update process of the model to integrate the latest version of STS without losing user settings. Additionally general settings can be selected like the language of the user interface for the complete model. Administration functions are provided, e.g. license tests or the management of methods programmed by the user.

4.2 STS_Space

The tool STS_Space manages the allocation of production areas by constructions or parts of different sizes and shapes *Nedess et al. (2007)*. The production area is modelled as a rectangular matrix with a flexible size of matrix fields. Using this approach it is possible to consider the allocation as accurate as needed. Within the space specific areas can be defined for different purposes e. g.

- blocked areas where nothing can be placed (crane posts, buildings, ways, et cetera)
- areas for special purposes (building sites, storage areas, et cetera).

The space tool provides automatic allocation of the space by a set of predefined rules which can be adjusted by the user. Additionally a graphical functionality enables the user to place certain constructions or parts manually.

4.3 STS_AssemblyControl / STS_ConstraintManager

The simulation tool STS_AssemblyControl was in the first phase delivered in close cooperation with Delft University of Technology to manage a variety of parallel assemblies considering individual rules with just one tool *Hertel et al. (2005)*. The basic assembly management is done by process patterns which can be defined by the user. These process patterns can optionally be structured by defining a certain sequence of assembly stages. The assembly stages consist of work steps associated to part types which optionally can be executed in parallel to a definable extend. By the process patterns assemblies can be standardized without losing the possibility to define individual strategies for special assembly procedures.

As there are possibilities provided in most STS tools the functions of the STS_AssemblyControl can be tailored to the specifics of every application by programming user-defined controls. By these controls the assembly process can be modified in many ways to fit the problem's needs.

In order to consider the multitude of constraints ruling complex assembly scenarios the STS_AssemblyControl can be combined with the tool STS_ConstraintManager, *König et al. (2007)*. This tool assures the fulfillment of constraints to execute assembly work steps. There can be several types of constraints to be managed like

- predecessor and successor relations between work steps,
- simultaneous starts of work steps or
- limited amount of parallel work steps.

4.4 STS_Crane

One of the most important transport means in shipbuilding or in comparable industries is the crane. Several different types of cranes are used and are to be considered in the simulation. For this reason the tool STS_Crane was developed and integrated into STS. Using the STS_Crane four different crane types are covered:

- gantry crane
- overhead crane
- tower crane
- movable luffing and slewing crane

Crane moves between different locations can be managed in the simulation model easily by inserting a requirement for the part to be moved and its destination. Allocation of a sufficient gantry – if more than one is defined – and the crane motion itself is managed automatically. To consider specific transport requirements typical at shipyards there are additional function available as options:

- crane moves using more than one gantry
- turning parts during crane moves
- definition of specific transport paths
- coordination of multiple gantries on up to three levels on top of each other

4.5 STS_Statistics

The output data collected during a simulation run is standardized in the tool STS_Statistics. This utility in embedded in all of the simulation tools that provide material flow or resources. The collected data contains inter alia

- the utilisation of resources (time slice for each state of the resource),
- part statistics (start time, end time and duration for each part and process),
- chronological changes of selected parameters.

The collected data can be visualized by a selection of different types of diagrams, e.g. pie charts, Gantt charts or bar diagrams.

The statistics of the complete model can be collected in the simulation tool STS_ModelStatistics. Functions for the comparison of output data from different simulation tools can e.g. be used for bottleneck analysis. The simulation tool STS_ModelStatistics also provides a functionality to create standard reports from simulation runs and an interface to export the output data into external software systems for further analysis, distribution or storage.

5. Examples for application scenarios

Using the STS simulation tools, a variety of application scenarios can be covered. Some typical scenarios from shipbuilding are described below.

5.1 Part fabrication

The build up procedure of a simulation model of part fabrication processes follows the production flow and its required facilities. Plants like cutting machines or profile cutting robots are inserted into the model by drag and drop. The inserted tools are then adjusted to the requirements of the specific fabrication scenario. For example, the cutting machine for plates provides parameters like

- cutting speeds depending on the thickness of the plate,
- speeds for additional processes like marking, signing or grinding or
- times for setting up the complete machine or the particular tools.

Additional to the process related parameters the layout of the cutting machine can be configured to the requirements as well. The size of the machine, the number of carriages or the selection or positioning of the tools on the carriages can be defined for each particular machine.

The STS tools for cutting machines or cutting robots also provide an interface to the original NC code for the real machine. The movements of the plant and the executed processes can be taken from the original control data to get a more accurate result and to take the specifics of the fabrication program into consideration.

If the logistics in the simulation model are to be considered, the transport of the stock material or the parts can be executed by STS_Crane, a forklift controlled by STS_TransportControl or STS tools for conveyors. The buffering of the material could be modelled by the STS_Space if space allocation is to be analyzed.

5.2 Assembly of steel constructions

The assembly procedures of steel constructions dominate large parts of the production in shipbuilding. The constructions are usually assembled in a certain area of the shipyards using cranes. The components to be assembled are provided by heavy load vehicles, forklifts or trucks depending on their size and weight.

STS offers a set of tools to model assembly processes for steel constructions. The main aspects of the assembly can be modelled by the combination of the simulation tools STS_Space, STS_Crane, STS_AssemblyControl and STS_ConstraintManager as described in chapter 4 (Fig.4). The required personnel can be provided by the tool STS_PersonnelControl.

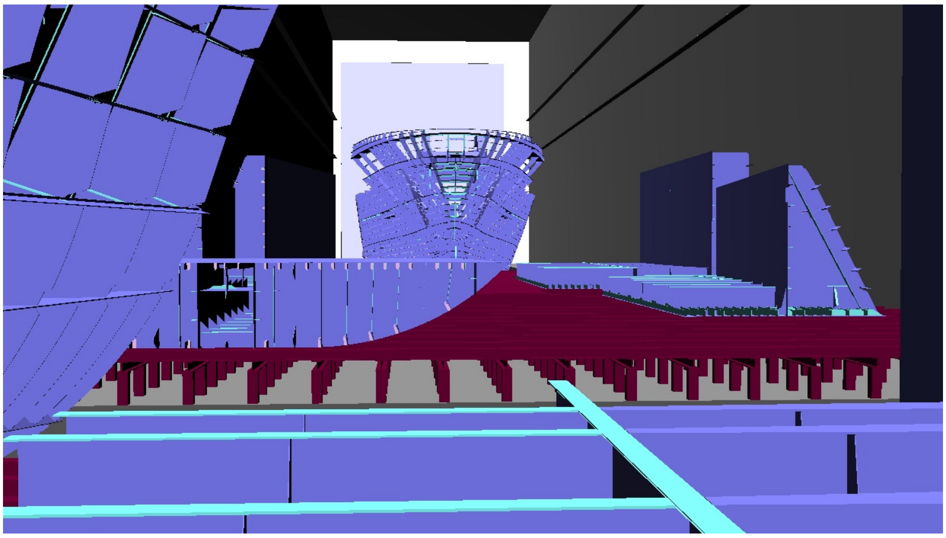

Fig.4: Simulation model of the block assembly station at Flensburger shipyard in 3D animation

If the logistics for the provision of the components is to be considered in the simulation model the following tools can be inserted:

- STS_MaterialAdministration for managing the availability of the required components,
- STS_Street respectively STS_Crossing or STS_Way for modeling the transport network within the model and
- STS_TransportControl for organizing the transport means and transports

5.3 Space allocation

Space allocation is a typical challenge in production planning not only on shipyards. The steel constructions of a ship vary a lot in size and shape and they have to be placed in halls with restrictions in door sizes, floor configuration or site arrangements. Movements of constructions still have to be possible and not too much space is to be wasted. The dynamic aspect of constructions to enter and leave on different times increases the complexity a lot compared to a simple nesting problem.

A simulation model built using STS can support this production planning task by providing space allocation functions, automatic placing strategies and the analyzing functions for the utilisation of resources and the compliance with the schedule. The models can be built up by one or more instances of STS_Space, possibly combined by logistic functions if this is to be taken into consideration. The specific rules for space allocation in the regarded production area can be programmed in user controls or defined in specific rule definition tables. Predefined allocations from other systems can be imported and considered in the simulation as well.

5.4 Outfitting / Refurbishment

Outfitting processes are distinguished by interferences, disturbances, great interdependencies and different surrounding area requirements, *Steinhauer (2010b)*. A multitude of requirements such as technological dependencies, resource and work space assignment have to be considered. In addition, the assignments of employees and equipment have to be regarded as well. Consideration of all the different restrictions and requirements result in a wide choice of practicable outfitting schedules. Detailed simulation of outfitting processes is challenging for two reasons: first of all the complex restrictions and requirements of the outfitting procedures have to be modelled and secondly the data about the outfitting parts and their dependencies are often not at all or not sufficiently available.

Building a simulation model of outfitting processes starts by the definition of the processes and constraints based on the product's structure. For the process definition there is a generic method implemented in order to minimize the effort. Work steps for typical part types are defined including the required resources and process times or algorithms for the calculation of process times. Those work steps are combined to process patterns. These process patterns are supplemented by a set of default constraints between the work steps not only to define the typical sequences of work steps for one part but also to define general constraints between work steps. Based on the part lists for the assembly and a classification structure for parts the predefined process patterns can be applied to generate the complete list of processes automatically including their default constraints. These constraints are then complemented by the specific constraints for this outfitting compartment or the regarded system.

The simulation model executing the work steps is built of the simulation tools STS_AssemblyControl, STS_Space and STS_ConstraintManager combined within the simulation tool STS_Compartment. This STS_Compartment represents one part of the building or ship to be outfitted.

The simulation approach for outfitting was recently applied for building a simulation model of refurbishment processes on a passenger ferry, Fig. 5. Before the work steps for outfitting can be executed the disassembly of the existing cabin area has to be carried out. The process data and model for this application could be defined and built as described above for the outfitting processes. The simulation tool STS_AssemblyControl also provides functionality to run work steps for disassembly which have to be related to the outfitting work steps by additional constraints.

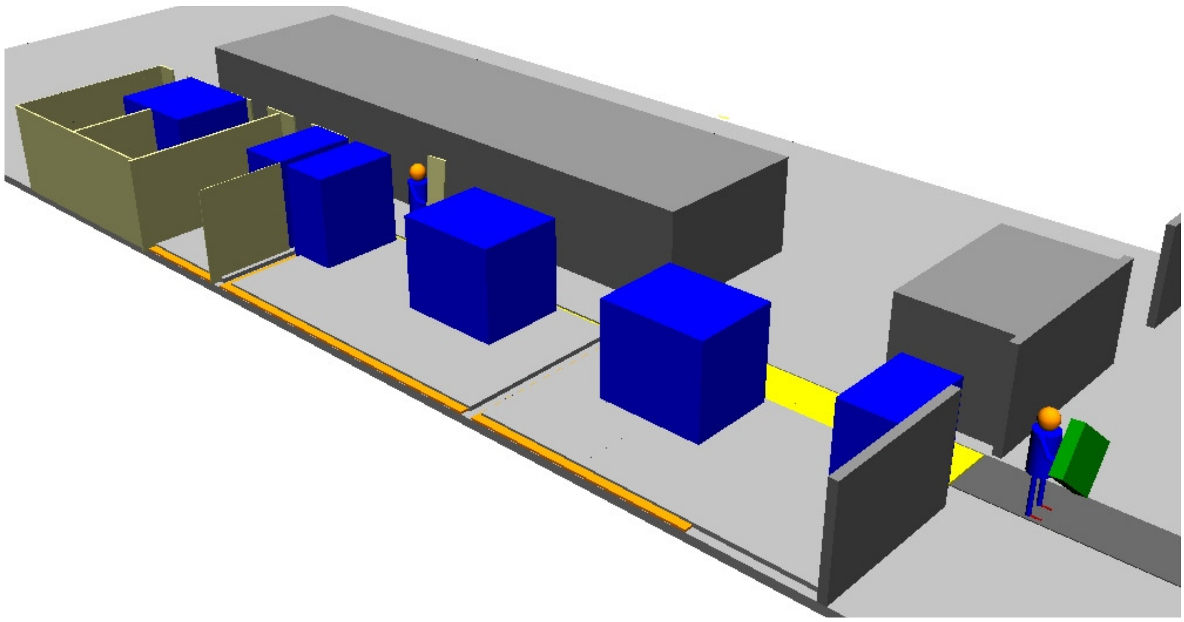

Fig.5: Simulation model of refurbishment processes in 3D animation

6. Integration of the simulation model into the data environment

Additional to a verified and validated model the input data is of major importance to get sufficient simulation results. Especially when using the simulation as a support for production planning and control the acquisition of the current data about the product, the production planning and the resource availability is as much necessary as challenging. At Flensburger shipyard the data is continuously collected from the different IT systems into the so-called Simulation Database by various interfaces. The STS tool STS_Data provides interfaces to select and import this data into each simulation model.

Because the availability and acquisition of input data is the major obstacle in using simulation at shipyards research was required in this field. In October 2009 the GeneSim (Generic Data and Model Management for Production Simulation in Shipbuilding) project started, funded by the German ministry of economy and technology (FKZ 03SX274), *Steinhauer (2010a)*. The GeneSim consortium covers a variety of shipyards working on completely different types of ships like freight ships, yachts or submarines. This group of shipyards is reasonably completed by a company very experienced in simulation consultancy and a university for the scientific support. All partners in GeneSim use STS for their simulation modeling.

In the GeneSim project the data required for simulation of production processes shipbuilding are to be defined and structured in a generic way by the partners from the shipyards supported by a university and a research institute. The data requirements of the simulation were derived by the data structure within the STS. The aggregation of data from the generic database of the simulation data is done in a way that is compatible to the STS.

7. Add-on tools to the STS for special applications

Additional to the basic function for the simulation of production flows in shipbuilding or in comparable industries the STS provides functionalities for special applications in terms of production or logistics. Internal projects at Flensburger or external projects for customers often worked as the point of origin for this kind of tools.

7.1 Loading and discharging – STS_Shiplog

Flensburger Shipyard not only offers a pure ship but a solution for a transport problem. Therefore the overall performance is a very important aspect in the design of the ship at Flensburger. The minimization of the port time can be a significant contribution to this overall performance. Flensburger shipyard has been using simulation of loading and discharging processes for many years in order to evaluate the ships performance and to optimize its logistics, *Soyka and Steinhauer (2008)*. The simulation tools for discharging and loading of ships are organized in the STS group STS_Shiplog and primarily linked to RoRo and RoPax vessels. The tools contain inter alia

- a loading control to manage the discharging and loading procedure,
- ramps including their logistical restrictions,
- a deck control to manage the logistics on a deck,
- areas for manoeuvring trucks of tug masters or
- storage areas on the deck.

Currently the tools for loading and discharging of ships are further developed in a work package of the European research project BESST (Breakthrough in European Ship and Shipbuilding Technologies) together with partners from shipyards and a research institute.

7.2. Logistics in ports – STS_Portlog

The ship-shore-interface gets more and more in the focus of the simulation because of its significant impact on the overall logistic chain. An increasing number of shipowners and terminal operators request evaluations concerning this interface. Therefore Flensburger Shipyard in cooperation with Technical University of Berlin have been developing simulation tools for port logistics primarily focused on RoRo or ferry terminals *Eckert, Fliege and Steinhauer (2008).*

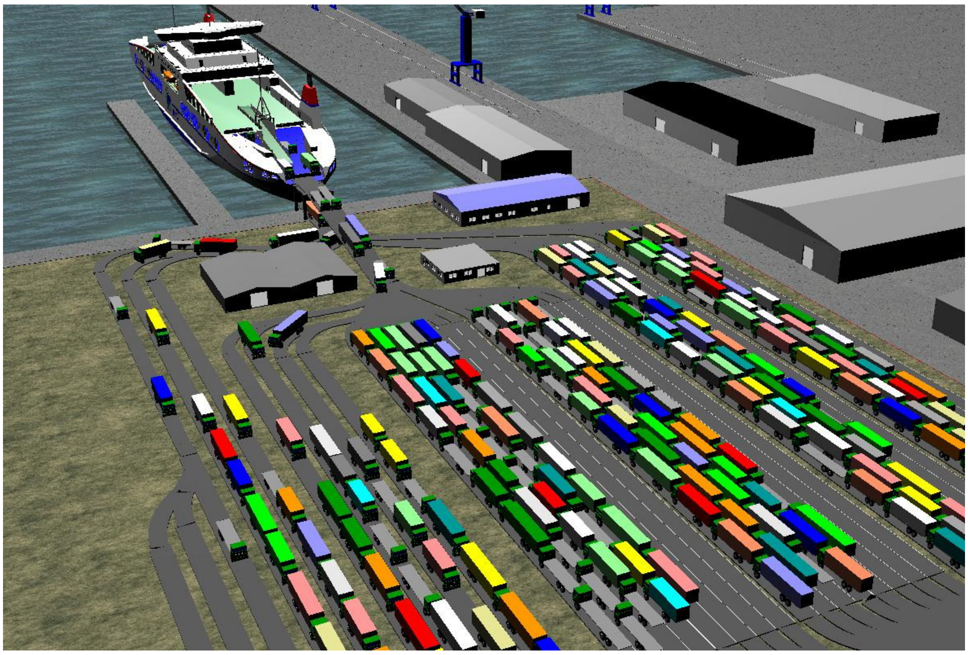

Fig.6: Simulation model of a ferry terminal in 3D animation

The tools for terminal logistics were successfully used in projects for customers already, Fig. 6. The overall cargo flow in RoRo terminals and the size of buffer areas were analyzed in these projects.

7.3 Installation of offshore wind parks – STS_Offshore

Due to design projects from the recent past, Flensburger's simulation team has performed simulation studies for the installation of offshore wind parks, Fig.7. Different alternative procedures of the installation process can be modelled and evaluated. All the parameters of the installation process can be varied like the type of the installation vessel including its attributes or the strategies for supply or assembly. Many constraints and restrictions can be taken into consideration in the simulation model. In these special applications the weather influence is of major importance. By evaluating different alternative scenarios the over-all installation process can be optimized with respect to shortest installation times and highest robustness of the schedule.

One simulation tool having its source primarily in the offshore wind park projects is the tool STS_Weather. By using this tool weather parameters can be imported respectively generated and afterwards considered in the simulation. For this consideration different possibilities are provided:

- The weather parameters can be aggregated to so-called weather conditions which can be constraints for a certain production process. The jacking process of an offshore vessel can only be executed up to a certain wave height and wind speed. Work on the facing of a building can only be done up to a certain wind speed and not when it is raining.
- Certain weather parameters can have impact on certain process parameters. The speed of a ship depends on the wave height or the drying time for concrete depends on the air temperature.

As sources for the weather parameters real or calculated weather parameters for the relevant locations can be imported. Functions for stochastic weather calculations can be used as well.

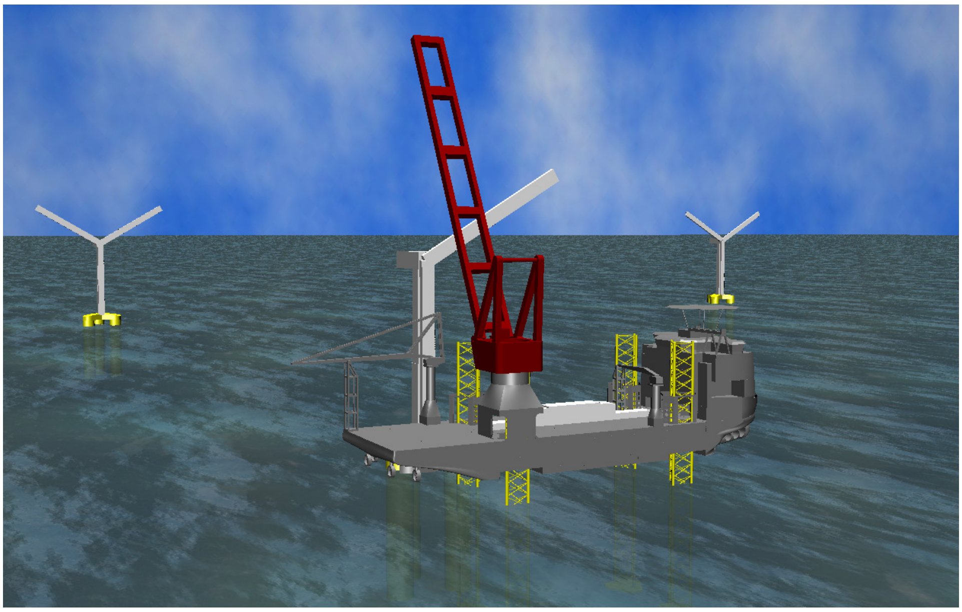

Fig.7: Simulation model of an offshore wind park installation process in 3D animation

8. Outlook

Currently the further development of STS is strongly related to the cooperation with the civil engineering. Tasks like central resource control, model generation from external data sources as well as flexible construction site logistics are being worked on at all partners of the SIMoFIT cooperation.

One continuous task in the STS development is to increase the performance of the simulation tools or their communication. Still large and complex models require a long time for a simulation run which limits the search space for model parameters to be varied in order to improve the simulation results for a certain task. Latest improvements in the basic software Plant Simulation will be tested and used in order to gain maximum simulation performance.

There is an increasing interest in the maritime industries as well as in comparable industries for the application of simulation for optimizing processes or for improvement of the production planning. In projects for other companies or in possible future interbranch cooperation, STS will improve its functionality and integrate new functions with respect to the new applications.

References

ECKERT, C.; FLIEGE, F.; STEINHAUER, D. (2008), *Simulation of logistics processes in RoRo terminals based on building blocks*, 13th ASIM Conf. on Simulation in Production and Logistics, Berlin, pp.101- 110

HERTEL, E.; STEINHAUER, D.; NIENHUIS, U. (2005), *Simulation of assembly production at shipyards*, ICCAS, Busan, pp.121-134

KÖNIG, M.; BEISSERT, U.; STEINHAUER, D.; BARGSTÄDT, H.-J. (2007), *Constraint based simulation of outfitting processes in shipbuilding and civil engineering*, 6th EuroSim Congress on Modeling and Simulation, Ljubljana.

NEDESS, C.; FRIEDEWALD, A.; WAGNER, L. (2007), *Modellierung und Simulation von Produktionsflächen im Schiffbau*, PPS Management 12/2, pp.36-39

STEINHAUER, D. (2005), *SAPP – Simulation aided production planning at Flensburger*, 4th Int.

Conf. Computer Applications and Information Technology in the Maritime Industries (COMPIT), Hamburg

STEINHAUER, D. (2007), *Interbranch cooperation for simulation of assembly procedures in outfitting of ships*, Hansa, September, pp.40-42

STEINHAUER, D (2010a), *GeneSim - Development of a generic data model for production simulation in shipbuilding*, 9th Int. Conf. on Computer Applications and Information Technology in the Maritime Industries (COMPIT), Gubbio

STEINHAUER, D. (2010b), *Simulation of outfitting processes*, European Conf. on Production Technology in Shipbuilding ECPTS, Rostock, pp.12-19

STEINHAUER, D; HÜBLER, M.; WAGNER, L (2005), *SIMBA: Entwicklung eines Simulationsbau-steinkastens für die Schiffsausrüstung*, Final Report, FSG, Flensburg

SOYKA, M.; STEINHAUER, D. (2008), *Simulation of logistic processes on board of vessels*, 13th ASIM Conf. on Simulation in Production and Logistics, Berlin, pp. 91-100