3D MARITIM – SUPPORTING TECHNOLOGY TRANSFER FOR 3D GRAPHICS

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SUMMARY

Innovation is a constant challenge for the companies acting in a global maritime market. Especially IT has proven to play an important role as an innovation driver by streamlining business processes and increasing productivity in nearly all industry sectors. However, selecting and adapting the most promising IT innovations is per se a challenge. For this reason it is a proven concept to build networks or clusters of stakeholders from different disciplines in a given region and for a given topic. By establishing a constant level of technology transfer and collaboration, the companies can reduce their risk and effort and increase their ability for innovation. The forum 3D maritim forms such a network that is located in Northern Germany and dedicated to novel applications of 3D technology in the maritime sector. The paper introduces the role of 3D graphics, presents 3D maritim at a glance and gives an overview over selected results of the forum.

1. INTRODUCTION

3D computer graphics is an enabling technology that has an enormous influence on all industry sectors from automotive over aerospace to consumer electronics. After significant improvements of engineering processes triggered by Computer Aided Design, Simulation and Digital Mock-Up we now observe an increasing level of research and applications in production-oriented scenarios under the initiatives of cyber physical systems and industry 4.0. Furthermore, the later phases in the product lifecycle such as training, maintenance and retrofitting also open up a big variety of sophisticated applications of 3D graphics – just to name virtual training environments or mobile support for maintenance technicians with Augmented Reality. Besides realtime visualization of 3D models, now capturing reality by means of laser scanners or (stereo) cameras becomes more and more important in the processes.

All of those IT innovations do not originate from the maritime sector. It is mainly the gaming sector that drives the 3D technology and induces radical improvements in performance for a fraction of the previous costs. 3D graphics cards, the Kinect sensor or game engines are obvious examples for this trend. The automotive sector is quite fast in bringing this new 3D power to industrial processes, especially. With a traditionally high level of IT related research and development (R&D) and large scale production this sector has a position as an early adopter of various 3D innovations.

But also the maritime industry offers a plenitude of opportunities to improve their processes by advanced information technology. However, a simple copy and paste approach does not work here. Maritime 3D solutions must always take into account the specific requirements of unique copies or very small batch series as well as the industry structure characterized by small and medium sized enterprises (SME). Technology-oriented networks are a proven success factor to increase innovation power and enable SME for joint R&D.

Such a network that deals with 3D computer graphics technology for the maritime sector has been established some five years ago in Germany. Under the label “3D maritim” it combines end users (especially shipyards), maritime service providers, IT companies and research institutes. This paper presents the activities and results of the 3D maritim network.

The paper is structured as follows: First we underpin the role of Information and Communication Technology (ICT) in general for economic development and the growing importance of 3D technology in the industry. Based on this we give some general information on the objectives and structure of 3D maritim. The next two deal with concreate results of jointly developing new technology for 3D in the lifecycle, namely in the phases of production and training. Finally we give an outlook to ongoing activities and end-up with conclusions.

2. 3D TECHNOLOGY

2.1 RELEVANCE OF ICT IN GENERAL

ICT is an important sector of all the developed economies [1]. Due to its nature of being an enabling technology, we have economic impact (GDP, employment etc.) not only in ICT itself but in all of the business sectors that make use of ICT. For this reason, the importance of ICT for our society cannot be overestimated. Studies for the US show that use of ICT has accounted for as high as 60% of annual U.S. labour productivity gains [2].

When applying ICT – and especially graphical applications – to the maritime sector, we have to keep several boundary conditions in mind [3]:

- Harsh environments (onboard a ship, in a shipyard, underwater) – relevant for user interfaces and optical sensors
- Limited access to broadband network connections – relevant for IT architectures (e.g. access to cloud services)
- Size and complexity of data sets for a whole ship – relevant for data management and visualization
- Most of the players are small or medium sized enterprises and not large enterprises as in the automotive sector – influencing capabilities for R&D
- The business is project oriented and not focusing on mass production – resulting in demand for flexible solutions
- The maritime sector is a global business with high cost pressure and many regulations (class rules, IMO rules etc.) – importance of governance

2.2 STRUCTURING 3D TECHNOLOGY

3D technology can be grouped into three main areas: Data generation via acquisition of real world objects (using cameras or scanner) or modelling tools (especially CAD), data preparation tools to change formats, manage distributed access or enhancing 3D models with simulated behaviour and last but not least 3D output in a physical way (3D printers, additive manufacturing) or a virtual way (displays in various qualities and sizes and investments into hard- and software together with 3D interaction devices).

Most of those technologies have their origins in the 70s but an enormous boost of technology started in the late 90s when 3D graphics became much cheaper due to the mass market of PC gaming. Figure 1 shows the steadily growing number of new publications covering 3D graphics topics [4].

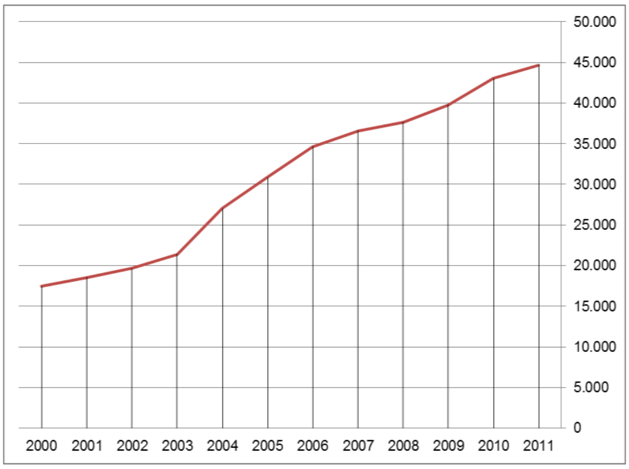

Figure 1: Worldwide scientific publications per year on 3D graphics [4]

2.3 3D IN THE MARITIME SECTOR

Especially the manufacturing industries already heavily rely on 3D technology in their processes. A study among German stakeholders in the maritime sector [5] showed, that system integrators (esp. shipyards) as well as suppliers (including SME) have a high level of penetration with 3D technology in those early phases of the product lifecycle. Later phases are characterized by much lower penetration levels. This is a clear indicator that there is no continuous flow of complete digital media in a 3D presentation between the stakeholders.

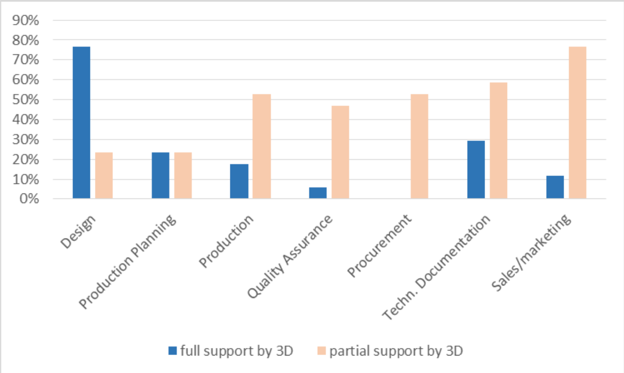

Figure 2: Penetration of 3D technology in several phases of lifecycle in the maritime industry [5]

3. JOINING FORCES

3.1. BASICS OF 3D MARITIM

The high potential of 3D technology for streamlining processes in the whole lifecycle of a maritime asset, combined with the specific challenges for introducing 3D technology in the maritime sector has been the starting point for forming the network 3D maritim. The network was formed in 2010 by companies from the maritime sector (Shipyards, suppliers), specialized ICT companies and research institutes. All members share the objective to grow the usage of 3D technology in the whole maritime sector. This is done by the following

- Collecting and distributing relevant information (on technical aspects, processes or markets)
- Sharing ideas and experiences on an informal basis
- Joint (applied) research
- Business development and marketing

For all of these activities, there is one essential prerequisite: Trust. For this reason, there have been various initial activities to build personal relationships between the members and lay the foundation for an open and fair collaboration.

Bringing together various stakeholders in a region (in our case: Northern Germany) for a given topic (maritime ICT) can form the nucleus for a successful cluster. The network supports the members by new ideas, collaboration in precompetitive R&D and access to global markets. Studies obviously prove that regions with a high level of connectivity and a well-defined cluster strategy outperform other regions [6]. It is important to state that 3D maritim does not form a powerful cluster by its own, but by interaction and collaboration with related networks and/or initiatives (e.g. Maritimes Cluster Norddeutschland) it contributes to.

3.2 GENERAL RESULTS

One of those trust-building activities in the initial phase was the creation of a joint vision. The core idea of this illustrated vision is a continuous and seamless use of a virtual ship that is created, maintained and used over the whole lifecycle of the asset. This vision has been prepared in a series of workshops, formulated as a storybook for a short film and then produced by a professional media firm (ref. figure 3). The result can be viewed at the website www.3dmaritim.de

Figure 3: Visionary use of 3D graphics in the phase of sales and marketing. Snapshot from the vision film

Another important result of the initial phase is a significant increase of interaction between the members. The following figure 4 shows the level of interconnection between the members when staring the projects and the successful effect of networking 30 months later. This developed network is a sound basis for many subsequent activities.

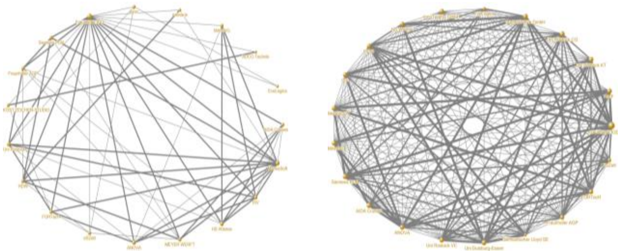

Figure 4: Connections between network partners when starting 3D maritim (left) and after 30 months (right)

3.3 MODUS OPERANDI

In 3D maritim there are different ways of organizing exchange and technology transfer. Depending on the specific task, we can select the appropriate method from a set of well-proven instruments:

Thematic workshops can be requested by the members or proposed by the executive board. They typically have a half day format and are used to put a topic on the agenda, present the state of the art by the involved researchers and maybe external experts and discuss if there is interest for further activities in the forum.

Working groups are established if a critical mass of partners is interested in generating a complex deliverable such as a project proposal or preparing a larger event. The working groups typically organize a series of workshops and collaboratively generate documents. After accomplishing the task, the working group is closed.

The general assembly once a year informs the members about the activities and results of various activities in the forum. Furthermore it is the place for strategic discussions and important decisions that go beyond the decision making authority of the executive board.

A conference and exhibition dedicated to technology transfer in the sector of maritime 3D applications is organized every two years in Rostock (www.go-3d.de). It brings together practitioners, developers and applied researchers and offers a forum for discussing recent results with internal members as well as external stakeholders.

For efficiently collecting information from the members or from a broader base of experts we use web-based online-questionnaires. This is especially helpful to get quantitative input (as used for figure 2). With an established tool chain it is quite easy to generate diagrams as input for internal decisions or for external publications.

A web-based collaboration platform is used to support working groups with a data exchange facility, including versioning but it also serves as an archive for documents (minutes, proposals etc.). The built-in Wiki functionality has not really been accepted by the members. An additional web-based service for idea management (members can post ideas or challenges and comment on postings of the other members) is an interesting add-on to support open innovation concept. However, due to unsolved questions of intellectual property protection it is not used up to now.

4. APPLIED R&D IN THE PRODUCTION PHASE

4.1 IT FOR MARITIME MANUFACTURING

Shipbuilding is characterized by its prototypical product development. The production of components often starts while the construction process is still running. This may result in disturbances as well as increased modification efforts in production. Technological requirements are permanently increasing so that construction processes and products become more and more complex. Furthermore, shipbuilding industry and its component suppliers work under enormous pressure of time and costs. Good market positions today are a question of well-trained and motivated personnel. New technologies, innovations, flexibility and the will to face new challenges enable German shipbuilding to maintain its position on the global market.

Virtual technologies provide great potential to increase productivity in the production process. The omnipresence of the internet as well as important developments in the sector of virtual technologies have led to a fourth industrial revolution (Industry 4.0).

In its focus are machine-to-machine communication and most of all the integration of the workers into the flow of information of the respective corporate IT infrastructure. The workers have to be provided on-site with all relevant information and data. This can only be realized by mobile solutions for the individual needs in shipbuilding. Two exemplary research projects on this topic that have been initiated by 3D maritim are to be presented in this paper.

4.2 COPING WITH GEOMETRIC CHANGES

The project Dyn3DPro [7] aims at developing an easy-to-handle Augmented Reality (AR) system. AR is an emerging technology that provides a virtual layer to the real world. It is extremely helpful to support human workers with information in their field of view that would otherwise would be presented in external data sources (handbooks etc.). The idea of AR is to track objects of the real world, provide additional information for a given work process and by this increase the overall quality and efficiency of the process [3].

The system is to serve as a construction tool and to allow real-time capture, presentation and processing of component data. One major challenge in the project has been data capturing and position determination via a tablet on the basis of the object's geometry. These steps provide details for the optical registration of the user concerning geometry. As soon as the position and orientation of the device (in the following referred to as "pose") has been identified, CAD geometries for active construction can be displayed via AR technology and processed on-site via additive constructions with suitable means of interaction (ref. figure 5).

A portable 3D laser scan system is used for capturing component geometry. The portability allows the scan of not only outside but also inside geometry, as for example in large cast parts. Laser scanning results in scatter plots which have to be registered and linked to the CAD data. The tracking of the portable laser scanner is a necessary precondition for navigating along large components and combining several scans. In the course of this, markers for local and stationary coordinate systems are necessary.

Figure 5: Augmented Reality in the maritime production

As to their compactness and simple, intuitive interaction, mobile devices, such as tablets or smartphones, are especially suitable for these tasks. For the workers these do not only provide the advantages of a target-actual-comparison but also the possibility to consult decision-makers with upcoming questions. The mobile device has to have a high resolution camera, a graphical interface and wireless access to internet. An optional feature is the attachment of light sources to the device in order to better illuminate the scene. Furthermore, mobile solutions are widely accepted as these are already widely used in the private sphere.

The captured data can be manipulated via the creation of plane and/or volume primitives as basic elements of a CAD-conform modelling. This would allow for direct design modifications of the respective component with the adjustments being implemented in the data in a quick and straightforward way. In the next step CAD model data as well as technical drawings are automatically created from the current geometry and are provided to an existing PLM system. This guarantees a consistent pool of product data.

4.3 CAPTURING REALITY EFFICIENTLY

The eKon project [8] aims at capturing the construction state of a ship's hull in real-time with the help mobile devices (e. g. by taking photos of the local surroundings). A hardware module is developed which extends the functions of common mobile devices. A smartphone or tablet thus will be able to determine its proper position and orientation within the hull – similar to a precise GPS sensor that can be used outside. The eKon module processes the captured data in a way to integrate them into a digital ship's model. Every single construction step can be documented automatically. This considerably eases the work of engineers and technicians.

A major challenge of the project is determination of the robust pose in a closed compartment of a ship. Within the raw steel environment the captured data are to reference in real-time to a superior coordinate system and to complete the model. In this course stereo cameras and various sensors, like e. g. infrared, air pressure or acceleration sensors, are applied (ref. figure 5). Besides all these data also the already existing knowledge about the spatial geometry is to be included into the system, image contents are to be synchronized and the camera movements are to be reconstructed.

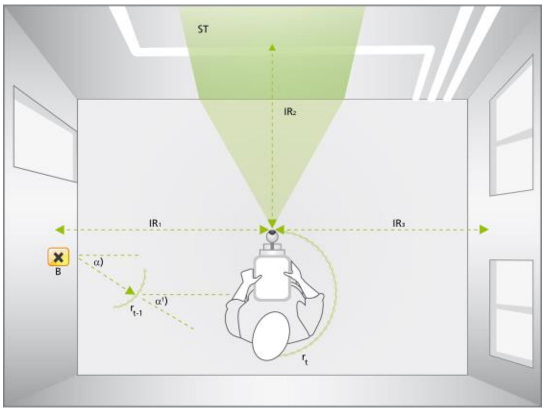

Figure 6: Using the eKon mobile device for efficient capturing the current assembly state of a compartment

The potential uses of the virtual technologies introduced in this paper even go far beyond the operation purpose just described. The project results can find further use in sectors like e. g. plant engineering, construction as well as the construction of large machines.

4. APPLIED R&D IN OPERATION PHASE

4.1 GENERAL APPROACH

With the rapid advancement of information and communication technology in the last years the resource “knowledge”, as an immaterial factor of production, became more and more important for each company. 3D maritim is supporting the handling of the company resource “knowledge”, not only to accumulate knowledge, but also to categorise, aggregate and reuse it again. Our perspective to knowledge management is a job-oriented approach with defined knowledge, skills and core competencies (ref. figure 7).

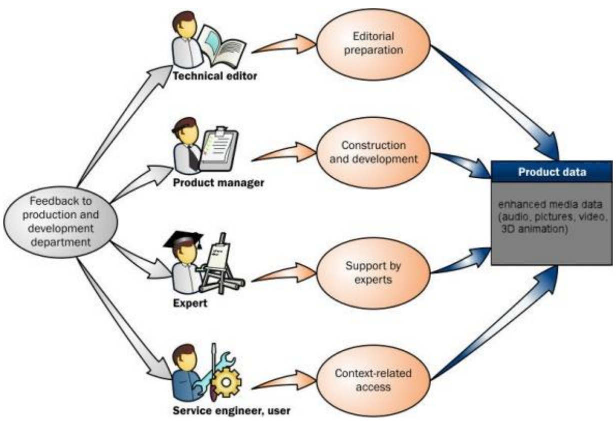

Figure 7: Different roles in creating, structuring and using product-oriented knowledge

These tasks have a lot of space for improvement by using 3D data originally generated in the design process of the vessel. The reduction of the amount of original 3D data is vital to be able to use 3D data for maritime education and training. The major areas of interest for 3D data models are:

- Familiarisation with processes or systems
- Operator training including exception handling
- Support for service and maintenance activities

Very often, the first introduction into a complex technical system or a new process is performed in a company – internal training centre. Currently three different ways are used to setup a training environment (ref. figure 8).

These different technical variants to make training allow different basic elements of an operator training for familiarization or specialized operator training.

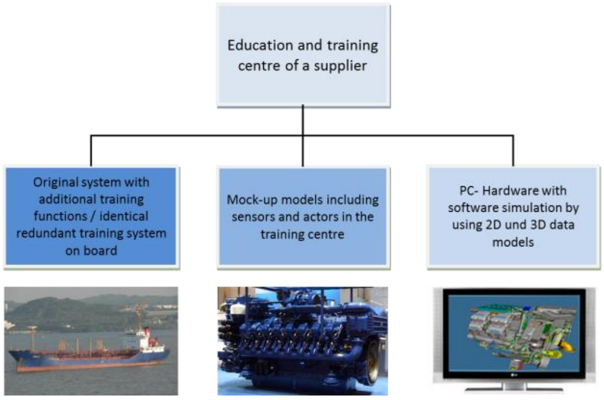

Figure 8: Three major facilities of an education center

As illustrated in table 1 the different training equipment offer different functionalities.

Complex training and simulation solutions by using 3D data provide a possibility to process, codify and to record both explicit and tacit knowledge because training and simulation solutions often use software in 3D models and using additional scenario generators.

Additionally to the real imaging of processes in the simulation, actions will be generated which are subject to the critical evaluation by a user. Their following actions affect the system’s behaviour. With the possibility to generate complex scenarios as single or team actions, it is possible to codify explicit and tacit knowledge. For describing scenarios, we use objective data and information, but knowledge about procedures and processes too.

To make a long story short: Virtual Models in the phase of familiarization, operation and training are about delivering just the right portion of knowledge to the right person, just-in-time, anytime, anywhere.

Original System	Mock-up Model	Virtual Model
Familiarisation with components and functions of the engine	Familiarisation with components and functions of the engine	Familiarisation with components and functions (3D Mock-up engine model)
Equipment training (Pump)	Equipment training (Pump)	Equipment training (Pump)
System training e.g. fuel system		System training e.g. fuel system
Training of emergency situation only quite limited	Training of emergency situation only limited on equipment level	Simulated training of emergency situations on system level
Anti - damage training only quite limited	Anti – damage training only on equipment level	Simulated damage training on full system level

Table 1: Comparing functionality of different training equipment

Operating procedures are faster to understand, when they are demonstrated. To see and to understand is better than to follow only textual descriptions. Working with 3D CAD data minimised the effort for the visualisation of products and processes. Units that are easy to understand support the presentation of knowledge modules.

The more complex the task is, the more important is the direct access to the suitable information. In order to notice a range of information the mobile access must be fast, easy and uncomplicated. Dealing with and handling of offered information should be done in a familiar way. Expectations by the users are a clear structure of content and navigation as well as an attractive presentation (ref. figure 9).

Figure 9: Mobile access to a virtual training environment

4.2 EFFICIENT AUTHORING

Another R&D project that has been initiated by 3D maritim is dedicated to the efficient authoring of interactive virtual training environments. The idea of MarOpTra-3D is to rely on existing data as much as possible [9]. Existing 3D models form the design phase should be "recycled" for training purposes. However, those CAD models are not created with the aim of training but with the aim to feed the production process (generate drawings, derive CNC programs etc.). This results in 3D models that on the one hand have too much details (e.g. information on tolerances and process parameters) and on the other hand they are lacking crucial information such as the behaviour of semantics.

As mentioned above, there are different roles in the authoring and usage of virtual training environments. We are aiming at authoring tools that will do not need knowledge in 3D graphics or game engines but can be used by domain experts. This can be accomplished by a modular approach that combines a conversion tool to reuse available CAD data, a tool for easily creating generic 3D geometry for a ship based on simple rules, a tool for creating learning scenarios, an editor that combines 3D models with scenarios for an interactive environment, a generator that translates the edited scene into code for a given runtime environment (e.g. a VR or game engine) and last but not least an assessment tool that tracks all activities of the trainee and compares this against the "perfect" solution.

This solution offers a high level of reuse for building blocks (3D models and scenarios. Furthermore, it also offers flexibility concerning the runtime environment: Even if the environment would change, most of the existing models could be reused and just a new generator must be implemented.

5. ONGOING ACTIVITIES

5.1. ROADMAPPING

The forum maintains a R&D roadmap that is structured in the following areas: basic technologies, specific technologies, applications (for shipbuilding, ship operation, training, and underwater), and mid- to long-term visions. This living document is used to coordinate R&D activities in the forum but also to inform external players (e.g. funding agencies, politicians) about our technical work.

5.2 BLUE JT

A long-term initiative of the forum 3D maritim is working towards our vision of a digital ship that would support the whole lifecycle of a maritime asset form design to recycling. This initiative can be broken into several technical or organizational challenges, including controlled access to the intellectual property, finding a fair value for digital assets, defining new digital services accompanying physical goods, long-term archiving of digital data an much more.

One concrete activity is promotion of the ISO standard JT [10] – a lightweight format for 3D data that has been developed for the needs of the automotive industry where it is currently used in a growing number of use cases. First studies and workshops have already shown that JT forms a good basis especially for exchanging product data between a shipyard and the suppliers. JT models typically cover less information than CAD models. This does not only reduce the necessary bandwidth or memory footprint but also solves some of the issues with intellectual property protection. However, the maritime sector needs some specific add-ons (working title “Blue JT”) to the standard to make it really useful in practice.

5.3 INDUSTRY 4.0/DIGITAL ECONOMY

The broad availability of cheap 3D devices, coupled with concept of a digital twin of the physical product (a ship, an offshore platform etc.) is one cornerstone of the initiate Industry 4.0. By offering means for constantly switching from the real world to the virtual world and the other way round, there are a lot of opportunities to improve traditional processes. This affects the whole lifecycle of the maritime asset and could change the way we are doing business in the 21st century – in the digital maritime economy.

6. CONCLUSIONS

This paper has presented 3D maritim, a forum of end users from the maritime sector, specialized ICT firms, and research organisation in the area of 3D graphics. They collaborate to unlock the potential of 3D technology in our specific market segment. To be successful with new technology in a cost-sensitive and regulated environment all the stakeholders have to join their forces and build knowledge pools.

Even though it looks quite focused on the first sight, it is a complex topic with a lot of demand for applied R&D and with applications areas from the first concepts models over production up to operation and recycling. By this 3D technology can make significant improvements to various processes in the maritime sector and also opens up opportunities for new business models in the digital economy.

7. ACKNOWLEDGEMENTS

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