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VIRTUAL AND AUGMENTD REALITY IN THE MARITIME INDUSTRY

Keywords: Virtual Product Creation; Virtual Reality; Computer Graphics

Abstract

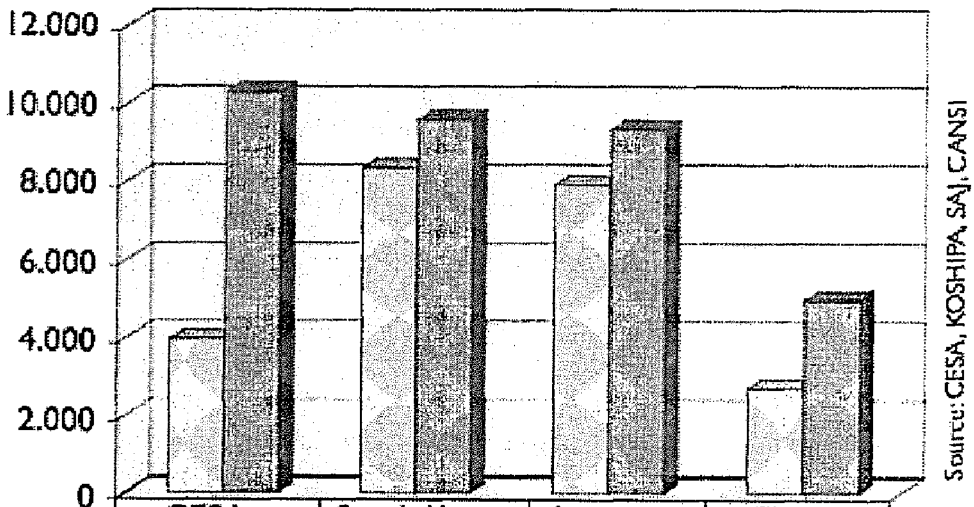
Computer Graphics is an important technology for progress in virtual product creation. Visualization and interaction with digital products are crucial to detect and solve problems in the design and the manufacturing process as early as possible. The concept of the virtual ship offers plenty of potential to improve communication amongst the involved disciplines, to compare alternative designs and to simulate production steps as well as usage of the ship and different situations. Highly interactive technologies such as Virtual and Augmented Reality are available and can be applied throughout the whole life cycle. This paper summarizes the state of the art from a technology perspective and presents typical usage scenarios ranging from design and production over marketing up to maintenance and training. Upcoming trends in hard- and software are highlighted and the paper concludes with an outlook to further research in this challenging field.

1 INTRODUCTION TO INDUSTRY SECTOR

The Maritime sector consists out of various quite diverse areas such as shipbuilding, shipping, transport and logistics as well as the offshore industry. Due to its' role in international trade as well as a producing industry with strong manufacturers with a large number of suppliers, it has been and will continue to be of strategic importance for Europe. With our focus on virtual products in this article, we concentrate on shipbuilding and mostly neglect the others areas.

„Shipbuilding is a key maritime industry which has contributed significantly to Europe's maritime past and which is strategic for its maritime future." [AP00] This industry is dealing with extremely large and complex products – comparable only to plants or large aircrafts. The market is characterized by a strong international competition with strong "newcomers" Korea, Japan and China, now dominating important parts of the market. However, if we refer to figure 1 we see, that European shipyards (labelled as CESA) we see that the Europe mainly concentrates on high-value ships whereas the "simple" vessels are mainly built in Asia. Although the European production in 2004 slightly decreased by 10% compared to

2003, reflecting the weak demand two years ago, European yards maintained the leading position in terms of production value [CES05].



* fiscal 2003 until 31.03.2004

	CESA	South Korea	Japan	China
Completions (in thou. CGT)	3691	8339	7897	2726
Turnover (in mill. EUR)	10,463	9,595	9,323*	4,970

Fig. 1. Regional Turnover in year 2004 [CESA]

Looking into the statistics of global shipbuilding output (ref. figure 2) we observe a steadily growing market since late 80s. Driven by the intense international trade and the increasing number of exports from China, the contracts for the next five years confirm this positive trend.

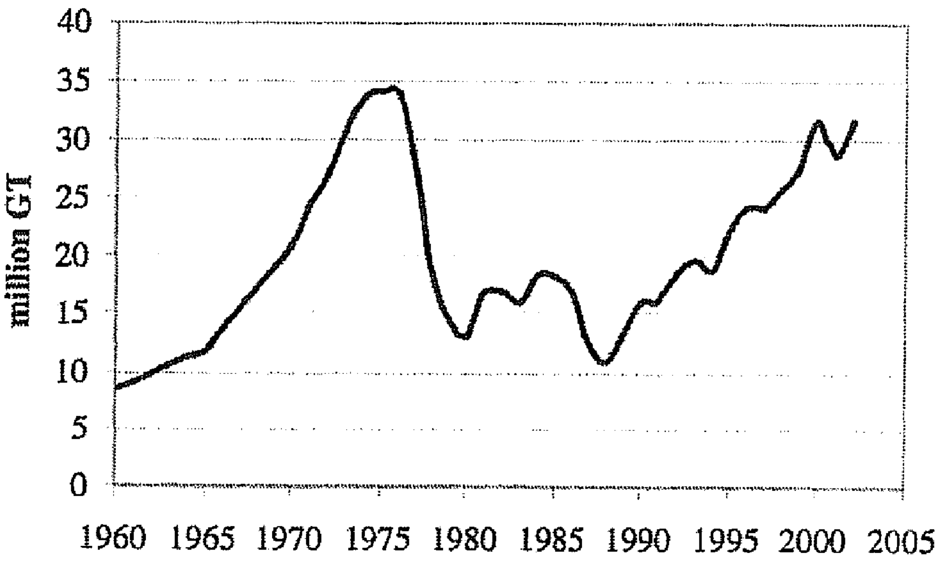


Fig. 2. Global Shipbuilding Output [FMI03]

However, if we compare this curve with the newbuilding price index (ref figure 3), we see prices have been cut dramatically since 1992. This can be explained by an improved productivity and even more important by large investments in new shipyards – especially in Asia.

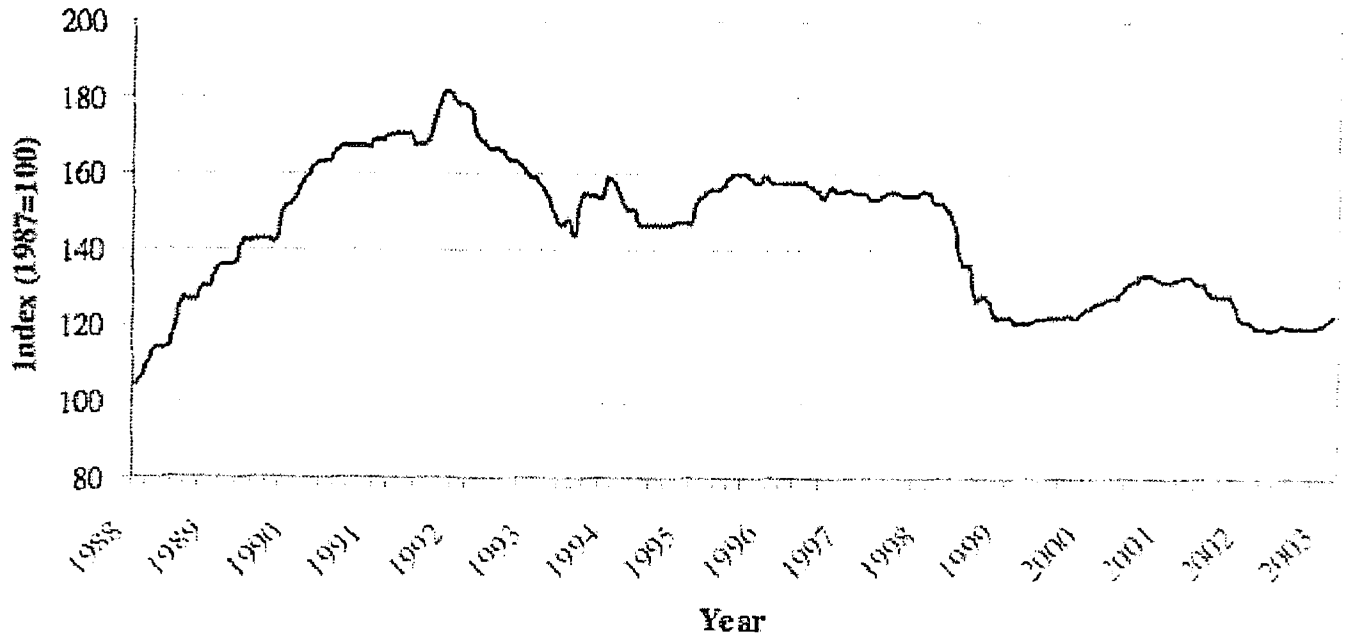


Fig. 3. Newbuilding Price Index [FMI03]

Summarizing the shipbuilding we find – on the positive side – a growing market where the demand of the ship owners is still increasing. On the negative side we have to deal with global overcapacities that exert extreme pressure on prices. Furthermore, the international competition is distorted by shipbuilding subsidies granted by the national governments in Asia as well as by the European Commission.

The European shipbuilding industry has identified a set of measures to hold and strengthen the position in the global market [EC03]. Innovation plays a major role in this context. New products and optimized processes are success factors in a hard global competition. In the remainder of this article we illustrate how advanced computer graphics technology can be used to support shipbuilding and later phases of the ship's lifecycle.

2. VR AND AR TECHNOLOGY

In this section we give a short overview over the state of the art in virtual and augmented reality and by this we explain various hard- and software solutions. Both technologies are closely related and differ in the degree of "virtuality" that is perceived by the user (ref. FIGURE). On the left edge we find the real environment with no virtual objects at all. On the right edge we have a complete virtual environment. In the middle we can build arbitrarily blend virtual and real objects. This middle part of the continuum is also denoted as Mixed Reality.

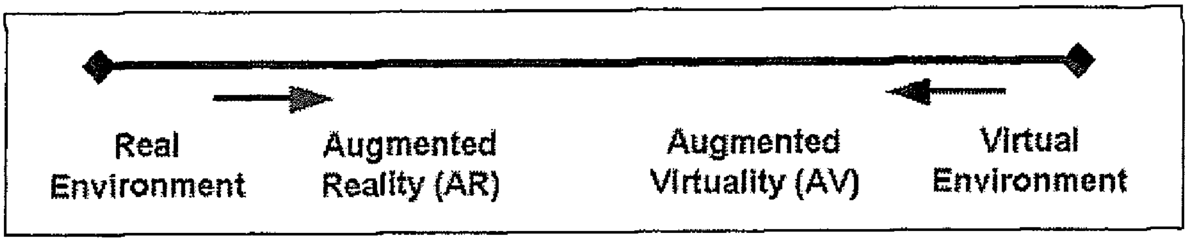


Fig. 4. Simplified representation of a "virtuality continuum" [MK94]

All the systems of this continuum can be structured using the basic model of [Enca93] with three dimensions

- Presentation
- Interaction
- Simulation

These three dimensions will help us to structure the following survey.

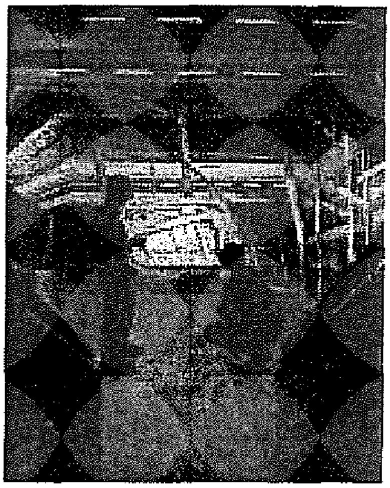
2.1. Presentation

The presentation system is in charge of presenting the virtual parts of the world to the user. Immersion is a measure of the degree to which information surrounds and includes a person through sensory means. Typically the visual system is the most important channel to offer a feeling of immersion. Here we can mainly distinguish between stationary systems for desktops or walls and mobile solutions, the so-called Head Mounted Displays.

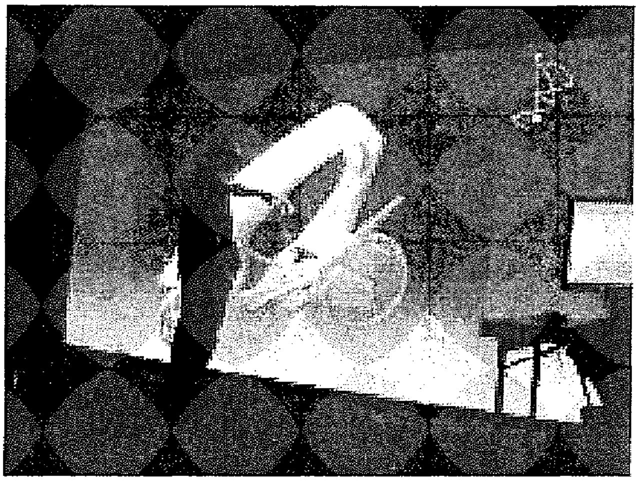
The best immersion we offer by means of a CAVE: A small room with stereoscopic back projection on 3-6 walls. Depending on the number of projection planes the user is fully surrounded by the virtual environment and is not disturbed by objects or events of the "real world". An approach quite popular especially in the automotive industry to support design reviews is the so-called Power-Wall: Two or more stereoscopic projection systems are tiled side by side and by this offer a large presentation plane. The HEyeWall [KRK03]

uses a similar approach and demonstrates the scalability by combining six by four tiles and 48 projectors and 48 PCs in total achieve a resolution of 18 mega pixel on a screen that is 5 meters wide.

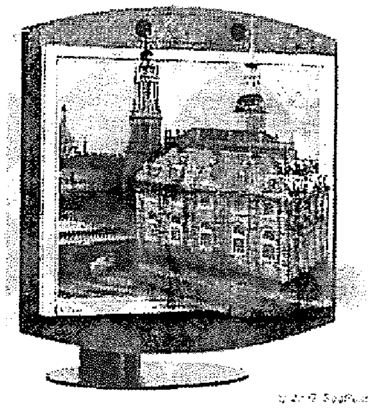
On the lower end of the immersion scale we find today a variety of auto-stereoscopic displays. Without special 3D glasses (shutters or filters) the user is able to see a stereoscopic image and get a natural impression of a 3D environment.



(a) 5-sided CAVE (Source: Fraunhofer IGD)



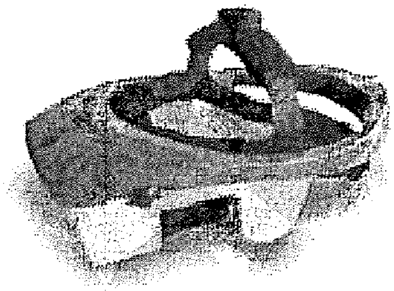
(b) HeyeWall (Source: Fraunhofer IGD)



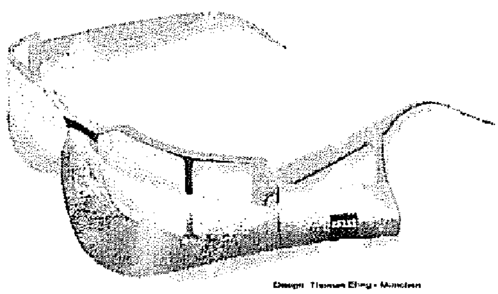
(c) Auto-stereoscopic Display (Source: SeeReal Technologies)

Fig. 5. Various Immersive Display Systems

For mobile solutions, the market offers various head mounted displays (HMD) (ref. Figure 6). Here the images are directly located in front of the user's eye(s). With small TFT displays or miniaturized projection system we do not need large projection walls surrounding to have a full immersive impression, but a device similar to glasses that will follow any head movement. By HMDs we can distinguish between closed systems for full virtuality and see through devices for augmented reality applications (ref. Figure 6).



(a) Closed HMD (Source: NVIS Inc.)



(b) See through HMD (Source: Carl Zeiss AG)

Fig. 6. Head Mounted Displays

These visual presentation systems can be combined with additional systems to support other senses for a complete virtual experience:

- Sound systems
- Motion platform
- Force feedback devices
- Smell dispensers

2.2. Interaction

Without interaction we would only have a passive presentation of objects. However, humans steadily interact with their environment: changing the viewpoint, grabbing objects, changing or manipulating the environments are important to make the virtual world as live as the real one. To support this, we have various sensors and interaction devices that are used in different settings, such as:

- Data glove
- Tracking system (electro magnetic or optical)
- PIP and Pen
- Game-Pad
- Gesture recognition
- Speech Input

By carefully combining a selection of those devices and support them with adequate interaction metaphors (e.g. direct manipulation of objects with a data glove), we can offer a high level of interactivity and usability in virtual or mixed environments.

2.3. Simulation

Up to mow we only have talked about the visual experience and the presentation of shape. However, a convincing virtual environment must also model the behaviour of the objects. That's where simulation becomes important. Some Virtual Reality systems already provide basic physic simulation, such as light simulation and rigid body simulation. For application-specific behaviour we have to integrate very specific simulators. These simulators also have to fulfil real-time constraints and for this reason, they typically have a simplified model that is close to reality but not too accurate. Examples of simulators, coupled to VR include:

- Manufacturing processes (robots, stamping or welding machines)
- Animated humans – populating a training situation
- Physical processes inside engines or pumps

Today, there is not a single technology how to integrate the simulator with the VR environment. Some systems rely on the High Level Architecture (HLA) standard for federated simulation, others us the native API (e.g. DLL) of the modules to visualize the simulation results in the VR environment and send interaction commands to the simulation engine.

3. APPLICATION SCENARIOS DURING THE LIFECYCLE

The first section of this paper has shown, that shipbuilding is a very important industry in Europe and that innovation in products in processes is part of the strategy to hold and strengthen the position in the global market. In this section we broaden the view and do not only look on the shipbuilding phase but on the whole lifecycle of the product, starting with sales and marketing and ending with operation and maintenance. For each phase we give some examples of applying advanced computer graphics technology to support the various stakeholders.

3.1. Sales and Marketing

Some market experts state, that sales and marketing is the most important application area of Virtual Reality in the near future. Creation a high-end presentation of the offered product or service is already done in premium markets (mega yachts, luxury houses) to attract the customer. This approach is now adapted to other products as well. Beside the (photo-)realistic images of a ship, we now find video sequences of animated ships, showing the exterior in interior design and also interactive presentations, where the ship owner can explore "his" ship before it is built. In the next step this model could not only be used for the ship-owner but also by travel agencies for marketing trips on a cruise liner.

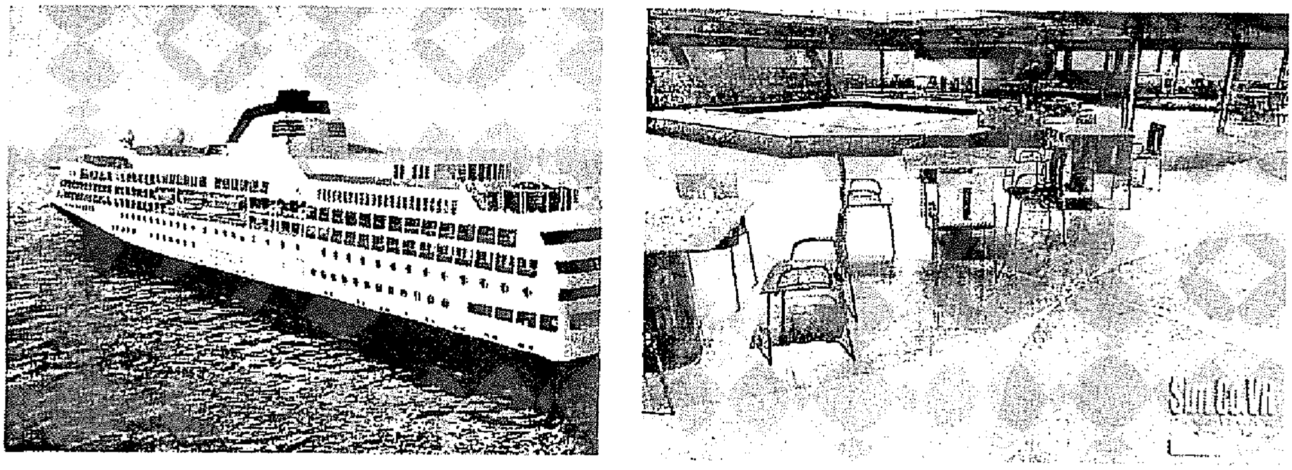


Fig. 7. Virtual cruise liner (source: ZGDV e.V.) and interior design study (source: SimCO.VR)

3.2. Design

The design phase is mainly determining the costs of a complex product such as a ship. Here the engineers have the chance to save huge amounts of money – by finding an optimized solution that is cheap to buy or to make – or they waste a lot of time and money – e.g. by making mistakes that have to be fixed during production and delaying the delivery of the ship.

The advantages of using Virtual Reality in this phase are twofold:

1. By presenting the current design in a large scale and by offering a high degree of immersion, the engineers can "dive" into the model and inspect it similar to reality, Collisions or other problems can be detected easily and a solution can be found with taking the whole context into account. In the virtual world eve non-CAD experts (e.g. the ship owner) can review the current design, compare different solutions.
2. Using Display systems such as powerwalls or CAVE-like environments (ref. Figure 8) we can efficiently support a group in their communication process based on the virtual product. Compared to a small desktop display it is easier to

share the model and discuss critical areas. Furthermore, we can link two or more VR installations to form a tele-conference and solve problems in a distributed team of experts located at various places [Luk05].

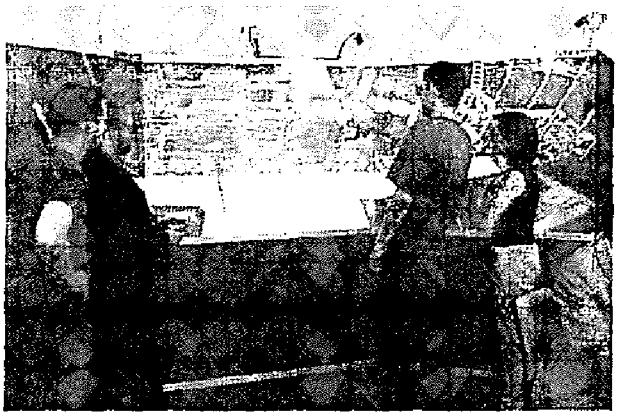


Fig. 8. Group during a design review (source: ZGDV e.V.), Checking accessability of a panel in the virtual ship (source: ZGDV e.V.)

3.3. Manufacturing

Most of the products in European shipbuilding are unique copies or delivered in very small series. So the shipyards can not spend as much time as the automotive industry to design an optimized production line, optimized tools and optimized workplaces. They have to build all their products based on their flexible facilities and have to find the balance between exact planning and improvisation for the production phase. Virtual Reality system, coupled with tools for production planning can be used here to validate and optimize production plans and procedures.

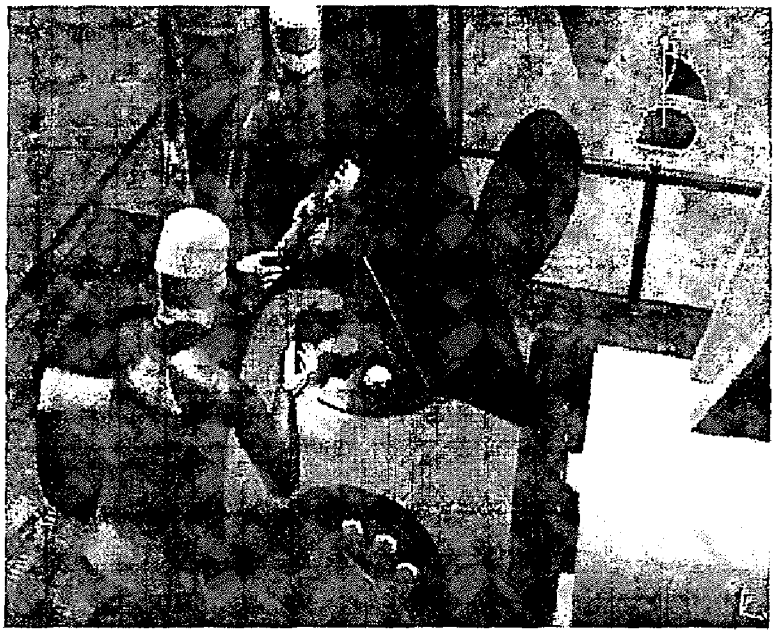


Fig. 9. Manual assembly simulation (source: Isselnord)

The following figure illustrates an example, where propeller blades are mounted. This is a very complex procedure, involving various workers, cranes and special lifting tools. By simulating the procedure in Virtual Reality, the process can be optimized to block the facilities as short as possible. Furthermore, the workers exactly know how to do the job after following the virtual reality simulation [IBM03].

The following figure illustrates the usage of augmented reality in the manufacturing process [AHG03]. The worker is assisted in welding by presenting him an optimized view on the welding beam (using image processing). Furthermore, he will see current welding parameters as well as suggestions for optimized parameters (angle, speed, ...) in his display. This is a very user-friendly application, where all the necessary information is available without changing the focus from the working area.

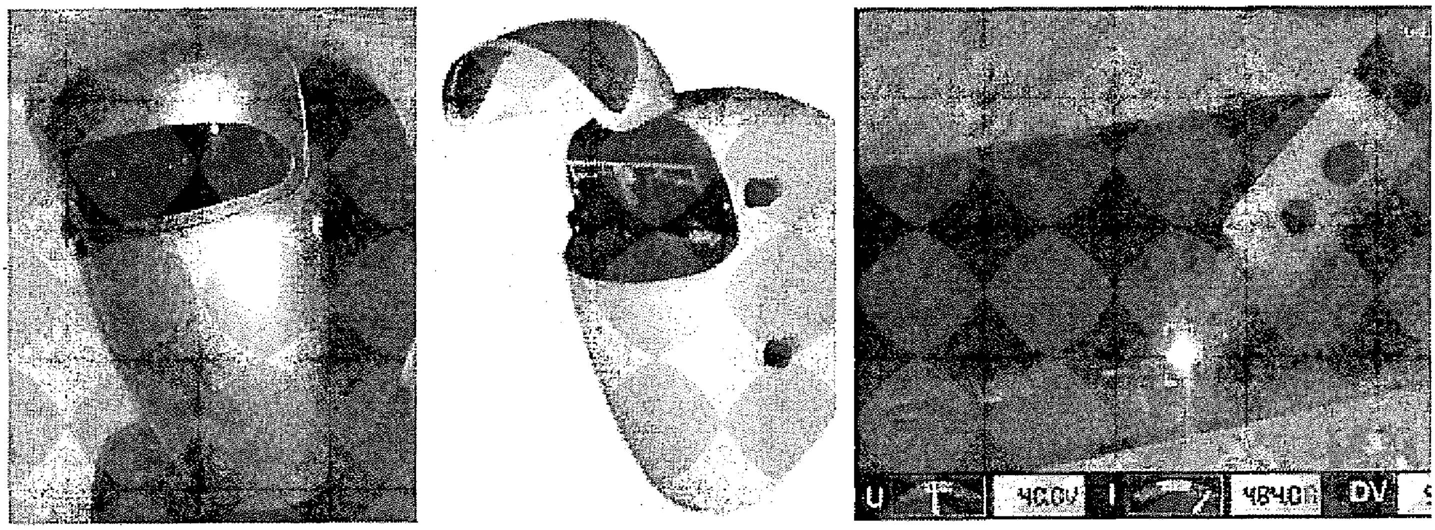


Fig. 10. AR-based welding helmet (source: project TREBES

3.4. Operation

Similar to the flight simulators, the ship oerators us VR-based simulators to train the crew members. This is done for the nautic staff and there are also some solutions to train the whole crew, e.g. in emergency scenarios. Here we couple the model of the ship (at least parts of the ship such as the bridge) with simulators for the behaviour of the ship (engine, speed, ...) and/or in special situations (fire on board) [Hel05].

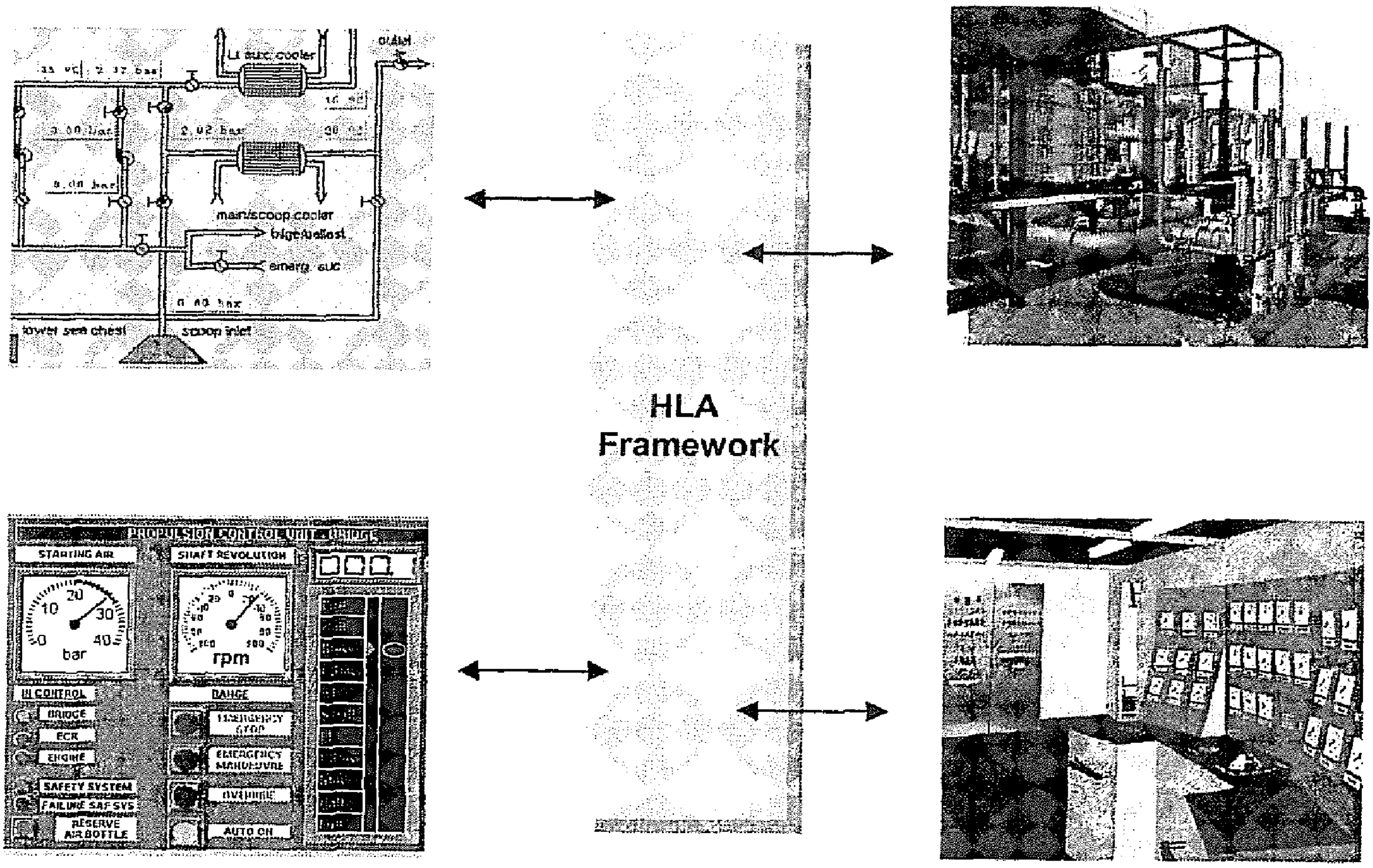


Fig. 11. Advanced training scenario with presentation and simulations modules connected via HLA (source: ZGDV/MarineSoft)

An important application field of augmented reality is the support of field engineers in Maintenance. Based on the 3D model of the ship (or parts such as the engine room), we can offer a multimedia handbook, where the work procedures are directly presented in the view of the engineer. As an overly to the engine he is looking at, he will get information where to check the oil or how to change a valve. This significantly accelerates the maintenance process – even with un-trained personnel.

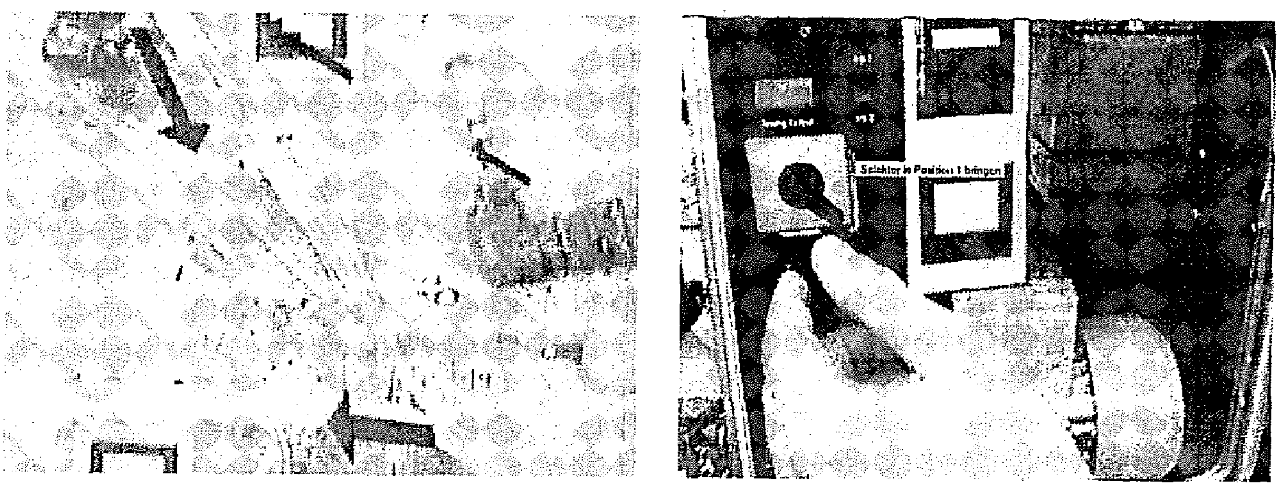


Fig. 12. Augmented Reality demonstrators for maintenance (source: project ARVIKA)

4. SUMMARY AND OUTLOOK

Based on some facts on the shipbuilding industry in Europe and an introduction to VR and AR technology, the author has presented various applications of those advanced computer graphics technologies in the life cycle of a ship. Obviously there is a great potential to improve processes and services starting from the marketing over design and production up to operation and maintenance.

It is important to mention that the virtual ship that consists of the 3D model, related product information and accompanying behavioural models is the core for supporting this wide area of applications. Even though some shipyards already have this model (even though typically not inn an integrated way) this model is not handed over to the ship owner. For this reason the potential is not exploited up to now. However, the growing number of attractive applications based on the virtual ship will illustrate the value of this digital representation and create a market for this important product.

Current research work is concentrating in the following areas [ELS05]:

- Increased usability and ergonomics
- Faster implementation of VR-based applications
- Robust video-based tracking without markers
- Integrated engineering workplace of the future tightly coupling CAD, VR and simulation
- Realtime rendering of high-quality images
- Standardized integration of presentation and behaviour models
- Fast and easy authoring of AR scenarios

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