Training @ Sea

Outside view for dredger simulator

1 The outside view in the IHC Systems training simulator provides the trainee with a realistic 3D image (note the shadows)

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Modern industries use dedicated simulators widely for crew training. The simulators in the aviation industry, in which pilots learn to operate new types of aircraft, are a familiar example. Formula One drivers also train regularly in simulators. The idea is to provide realistic training without the risk of accidents, production losses, damage to highly expensive assets, or even personal injury. Simulators often resemble the video and computer games that surround us almost everywhere but, in fact, they are very serious systems based on sophisticated physical models. So they also represent major investments. Nevertheless, they cost just a small percentage of the real thing. So it will be no surprise that the dredging industry – where standards for performance, power and precision are a match for the cutting-edge technology of Formula One – is at the forefront of industrial practice, and that it is using more and more of these systems. As well as the cost considerations, there are two other reasons underlying this development.

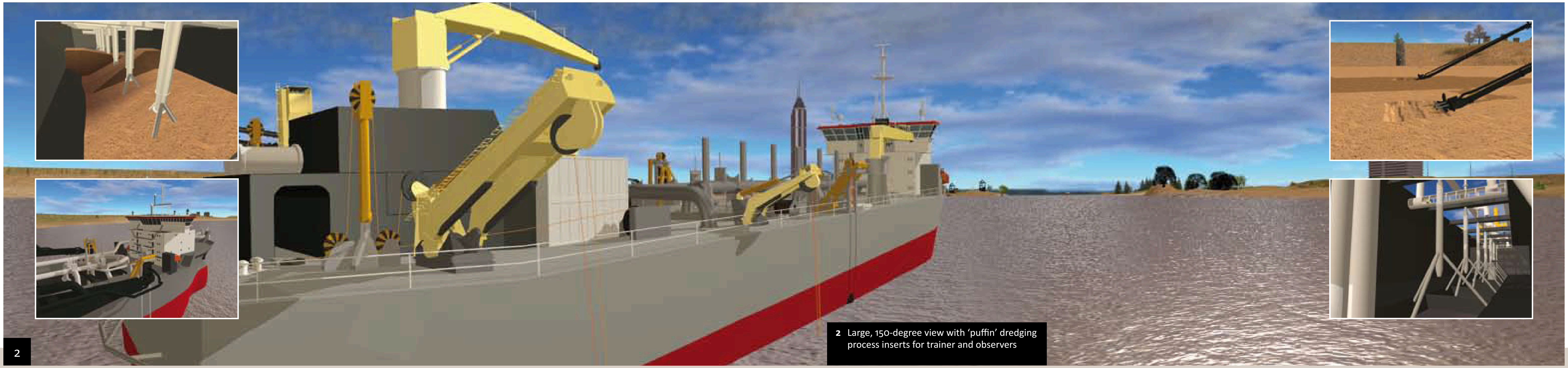
Firstly, there is no let-up in the pace of improvements in the efficiency of dredging technology, advanced designs, dredging components and integrated systems. These advances make high-efficiency, high-accuracy dredging operations possible, and make it possible to cope with more difficult soils and tougher site constraints. Advanced automation and control systems make it possible to use the innovative dredging equipment in efficient and sustainable ways in these circumstances, but final performance still depends on the crew and the project management. So high crew and staff competence – best described as a combination of proper dredging knowledge, skills and experience – are vital. Without extensive training, it is impossible to exploit the opportunities provided by modern dredging technology.

Secondly, the size of the projects and the huge equipment investment programmes are leading to an increasing shortage of crew with enough experience. So the need for recruitment and training is acute. Simulators have a role to play in both these areas.

Training Simulators from IHC Systems

Origin

IHC Systems is the IHC Merwede instrumentation and automation company. With its emphasis on being *dedicated to efficient dredging*, it spotted these trends in the early stages of their emergence, and anticipated them. So the first attempts to provide the dredging industry with simulators came in the 1990s. There was a sound basis to build on since the automation of the dredging process had been under way for many years. Increasing complexity meant that extensive testing was required to prevent delays in the commissioning cycle of the dredging vessels built at the IHC Merwede yards. So the people at IHC Systems began to develop models and software for the extensive testing of their own automation software. This expansion process received a major boost when the development began of adaptive controlled DP/DT systems for trailing suction hopper dredgers. At that time, the commissioning of a DP/DT system usually required the availability of the operational ship for a full week. To prevent mishaps during the launch of entirely new products, IHC Systems built a full simulator for the first time, incorporating hydrodynamic models and models related to the dredging process. They used it for the successful



2 Large, 150-degree view with 'puffin' dredging process inserts for trainer and observers

testing of DP/DT and the implementation of the associated learning curve. The result astonished the outside world: the ship was only needed for one day to commission the real system successfully. As a spin-off, this simulator was also used for training with DP/DT well before the ship actually went into operation, even to the extent of training for a real dredging job.

Business development

With the results so clear, and given the needs of the dredging industry described here, it was only rational for IHC Systems to start developing dynamic training simulators for the dredging industry. This venture was a success, and the first generation of simulators sold rapidly. Nine simulators are already operational. The Belgian contractor Jan De Nul owns training simulators for a hopper dredger, a cutter dredger and an excavator. Colleague DEME uses a cutter dredger simulator. Another hopper dredger simulator is in use in Zeebrugge at a public training institution.
IHC Merwede's Training Institute for Dredging (TID) and the Regional IHC Merwede Office (RIO) in China both have a cutter simulator for their training programmes. Of course, three simulators are fully operational at the IHC Systems premises in Sliedrecht, and other dredging contractors are becoming increasingly interested in the phenomenon.

General functionality

Training simulators from IHC Systems are used to familiarise operators with the manual control of the dredging installation aboard dredgers, to teach them to get the best out of automatic control systems and to train appropriate responses to difficult situations, failing equipment and calamities. For example, operators training to handle a TSHD learn about the complete loading and unloading processes, including suction pipe handling, the aspiration process at the draghead, jet water handling, the pumping process, hopper settlement, unloading through bottom doors, pumping ashore and rainbowing. At the same time, they learn to operate and debug the vessel's auxiliary systems and about the specifics of those systems.
A helpful feature is the feature for speeding up the loading and unloading process in order to accelerate the training. In addition, any process situation can be saved, and either be re-used at a later stage at the start of a new training module, or be played back for evaluation purposes.

Versatility

One of the main characteristics of the simulator is its versatility. It can house all the dredger's features such as the total number of pumps (submerged and in-board), the energising of the pumps with diesel engines or electric motors, multi-stage gearboxes, the length and configuration of the suction tube, the type of draghead (active or passive), the number and arrangement of bottom doors, self-emptying doors, and jet-water and dredging-circuit sluice valves. Interfaces with survey equipment, DP/DT, DTPS and ECDIS are options. The first generation was soon extended with a projector for training operators at the beginning of the learning curve, giving them the opportunity to observe the results of a colleague working hard at the control levers. Other options are the incorporation of sounds, and of vibrations in the operator's chair. These features result in a major enhancement of the impression of reality and they are particularly helpful in cutter dredger simulators.

Dynamic models

A simulator is meant to imitate the real ship, so the system is crammed with physical models that are interconnected and integrated in an overall model, providing a complete representation of the real-life dredger. These models were developed at the IHC Systems Research & Development Department using a range of sources: literature and standard modules from the public domain, knowledge from external knowledge centres, expertise and models from IHC Merwede's scientific R&D institute, MTI Holland. In some cases, simple linear or quadratic equations suffice. So there are standard hydraulic modules, dredging process modules, dedicated vessel modules, adjustable soil property modules, and pump, pipeline and valve modules. For trailing suction hopper dredgers, this complex has been rounded off with modules for the suction tube(s) and the swell compensator(s), the draghead and its visors, the hopper and the overflow, energy generation and consumption (including limits), jet water and so on.

Typical training

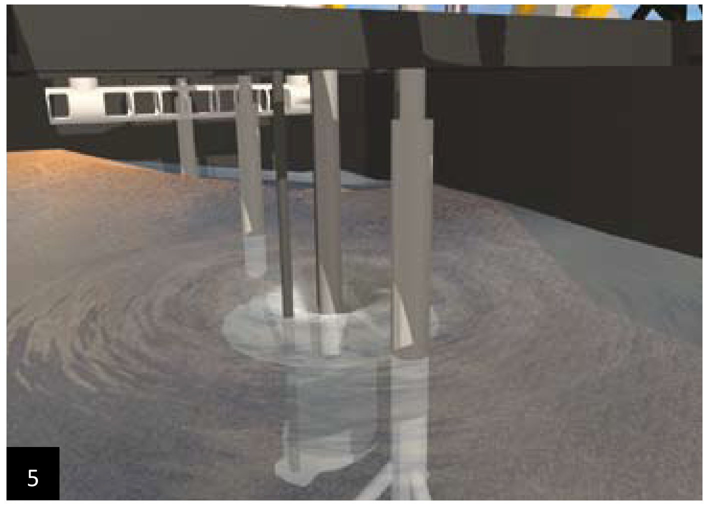
In a normal training session, the trainee operates the systems' control levers (*figure 3*), and the trainer has a dedicated trainer control desk for configuring a session. The session may cover a single process or a selection taken from all the components of full operational training. The trainee is expected to perform the required operations and to deliver a loaded ship – or an empty one – or to complete a full dredging cycle. Of course, during a basic training session, the trainer will provide the operator with a fully operational 'ship'. If the trainee's response falls short, the system generates calamities such as pipelines getting blocked, overloaded diesel engines and slipping couplings. As trainees start to feel at home with the virtual ship, the trainer lets them deal with equipment failures such as severed dragheads, jammed valves, failing sensors, or problems with start or running conditions. The trainer can initiate such events straightforwardly by adjusting module parameters at his 'soft' control desk. During the session, fellow-trainees can either follow 'straightforward' training, sitting near their hard-working mate, or more extensive training with a screen in the trainer's room. After a session, the system automatically generates a trip report and a report about performance in the training session.

Configuration

A typical IHC Systems simulator is built up on the basis of tried and trusted hardware and software that have proven their worth in automation projects over many years. They include:

- A complete copy of the dredger's control consoles and instrumentation panels.
- A Programmable Logic Controller (PLC), supervised by an Integrated Monitoring and Control System (IMC) consisting of several PCs, screens/touch screens and operator keyboard-trackball combinations connected to each other and to the PLC system by fast Ethernet.
- A powerful PC containing the 'ship', i.e. the models. This PC communicates with the IMC system and also with the PLC system by controlling and reading its 'soft' I/O. It contains a trainer interface. The simulator PC can also generate vibrations and realistic sounds recorded on board the real dredger and manipulated by the simulator's models depending on, for example, the calculated diesel engine load, winch speeds and pulling forces, etc.
- A desk for the trainer. Here, the trainer can initiate sessions, alter settings and introduce calamities and equipment failures by altering values on a 'soft' control console, which is in fact a mixture of physical presentations and the familiar dialogue windows.
- Optional computers can be hooked up to the network to generate outside views and artificial camera views (picture-in-picture). The IHC Systems outside view is unique in the simulator world because it realistically presents the amounts, structures and estimated colour and texture of material taken from one place, loaded in the hopper and then deposited at other places.

A new step: the outside 'puffin' view



3 Jan de Nul's inspiring trainer, Steven Quintijn, training on the simulator himself

4 The visualisation of the actual suction and cutting process

5 The overflow process shown on the basis of true calculations by the Artificial Intelligence-based overflow loss estimator from IHC Systems

The client for the simulator in Zeebrugge was the first to ask for an additional outside view. Once they saw it, Belgian contractors soon asked for a similar feature in the simulators they were already operating. Maintaining its high standards, IHC Systems dedicated a full R&D project to the issue, using new resources and tools for the purpose. New talent was recruited and employed for this technical *tour de force*. The result was the second-generation outside view for the dredger simulators. It had presentation features that may seem a little primitive now, but major progress was achieved in a short time. New tools, and knowledge which is common in the games industry and among physical modellers were adapted for this specific purpose. Nowadays, the option of a full outside view is available to all customers.

When clients ask for the option, the simulator hardware is extended to include a very powerful PC with magnificent graphics hardware and software. This PC performs the enormous calculations and directs the projector beams onto a 150-degree screen in front of the trainee (*figures 2 and 3*). This makes it possible to present a high-quality picture of the dredger, including 3D facilities such as depth and shadow (*figure 1*). The image is highly versatile and it can present the situation from any angle, whether above or below the water. This is the reason for the term 'puffin' view, which refers to this magnificent bird's ability to fly rapidly above the water, and its equal ease below the water.

The main characteristics of the 'puffin' view are:

- Realistic 3D presentation of the dredger and its subsystems, extendable to several ships in one simulator. This includes the presentation of layers of wire on winches, running wire sheaves, moving gantries, swell compensators and overflow ducts, dangling suction tubes, a connected shore discharge pipeline, and rainbowing – or a running cutter and side winches, etc. in the case of a cutter suction dredger. An excavator simulator shows a moving boom, stick and one of the tools.
- True process phenomena such as jet water flow, the mixture flowing into the hopper, the overflow water, water jets and the turbidity around the ship. In addition, a state-of-the-art approximation is provided of the mixture breach patterns in the hopper during shore discharging or rainbowing, divided according to the bottom door compartment. This true-to-life presentation is only possible because IHC Systems, as part of the IHC Merwede group, can draw on MTI Holland's extensive scientific knowledge and vast experience with sophisticated soil models.
- The possibility of immediate seawater run-off resulting in a complete, 'dry' underwater view. This opens the way to a host of additional features, such as the realistic presentation of operations with dragheads, visors and water flaps, and unloading. The true dredged track is presented (*figure 4*) using the calculation of all relevant process values and the parameters of the soil model.
- A defined dredging area set in a natural landscape that can be adapted to any client requirements and that can include any landscape elements from the public domain. The landscapes include varied climate conditions – day and night, clouds and light intensity. The weather type can be adjusted from bright sun to heavy showers. Of course, the sea state affects the vessel's behaviour in the basic simulator, but it also determines the appearance of the water in the outside view.

It is not possible to describe in words all the fascinating features included in the outside view. The illustrations accompanying this article provide a selective overview of the possibilities (*Figures 1-9*). *Ports and Dredging* thinks these illustrations are a convincing demonstration, even though still pictures cannot hope to render in full the dynamic potential of the simulator systems.

For realistic training, trainees should not see more than they would on board the dredger. Figure 1 shows the view they have during training. On the other hand, for evaluation purposes and for trainees looking over the shoulder of the trainer, it is considered useful to observe the physical effects of their actions. So the main presentation can be extended to include picture-in-picture (PIP) features: relevant subsystem 'puffin' views are inserted in the main display (*figure 2*), allowing for a comparison between the 'real' thing and the process pages in the simulator. This feature considerably enhances the rapid acquisition of an understanding of the ship's possibilities and limitations in practice.

Jan De Nul's training practice

Jan De Nul ranks high among the world's largest dredging contractors. It was one of the first companies to buy a simulator from IHC Systems. The technical and educational staff at Jan De Nul have set up a fully equipped training centre in the company's headquarters in Aalst, Belgium. Alongside the usual classrooms, it includes several simulator rooms, each of them dedicated to one specific type of dredging equipment, ranging from small, standard, simulators for dry-soil moving machines to the full range of IHC Systems dynamic simulators mentioned in the introduction. The more sophisticated machines were carefully designed in close cooperation between IHC Systems and Jan De Nul's simulator specialist, Ruben De Lille. The simulators in Aalst are mainly used for three purposes:

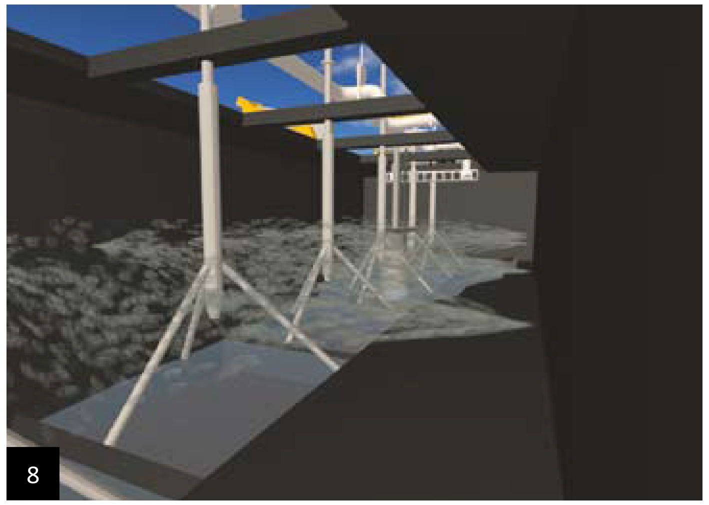
- *Actual training*: See below.
- *Motivation*: As a result of market conditions and the shortage of experienced crew, Jan De Nul must rely increasingly on personnel from abroad. Training them exclusively at the headquarters gives the crew a welcome feeling of being immersed in the company's culture and of being in touch. Steven Quintijn, Jan De Nul's enthusiastic and inspiring training engineer told *Ports and Dredging* that there are numerous training applications from the entire fleet. Not only from operators, but also from technical staffers, electricians and field managers. The result is that the classrooms are fully occupied throughout the year. The simulator is also used to draw in new talent to the dredging world – or to test them if they claim dredging experience.
- *Marketing*: Projects are prepared on the simulator for showing to clients. Survey data is loaded into the simulator and the client can see himself in his own backyard, observing the dredger, strolling around the scene and shaping the landscape according to his plans.

Perhaps the most important rule at Jan De Nul is: maintain production. This has become second nature to all employees. So the time loss involved in training new crew members on the expanding fleet cannot be afforded. And the risks involved with such capital-intensive assets are too high. A mistake during training on the job could shut down an entire project. Every minute and every cubic metre of sand counts, and the standards are so high that rookies must not be a hidden feature of daily reports from the ships. So it is the company's policy to cut down on the preparation time for newcomers and to train them extensively on simulators.

This policy is facilitated considerably by a spin-off of Jan De Nul's structured vision of many aspects of dredging. Starting with the 11,750m^3 trailing suction hopper dredger JAMES COOK, which was commissioned in 1992, all

6 Unloading of the hopper contents, seen from the hopper side...

7 ...and from beneath



8 Jet water visualisation

9 Rainbowing – the colour of the 'rainbow' reflects the mixture density that is actually discharged

10 The project 'Waterfront' in Dubai is one of the constructions, made by J de Nul's well-trained crew

the firm's dredgers have had an identical integrated monitoring and control system. Initially, this system was designed jointly by Jan De Nul and IHC Systems, and then further developed over time by the contractor's well-equipped staff. The advantage is that an operator going on board any vessel in the fleet can get to work immediately with a control and presentation system that he knows. To return to the simulator, the benefit is that a single generic control console and a single generic IMC can be used to train people from the entire fleet. Jan De Nul's drawings of all their vessels can be loaded in the simulator for integration and configuration by IHC Systems.
In Aalst, the trainer then can select the required vessel. Ideally, new developments are introduced throughout the fleet and on the simulator simultaneously so that the simulator keeps pace with the projects.

Steven Quintijn and his colleagues have established a balanced educational programme with the following main components:

- During the first six-week shift on board a real ship, a rookie is expected only to look over the shoulder of an experienced dredge master. A trainee who demonstrates talent and ambition may fill a hopper once under the supervision of the experienced master.
- The trainee's leave after this first shift includes a week in Aalst on a junior theoretical and practical course. The newcomer gets used to the computerised control environment and is shown how to control the hydraulic installation and the valves correctly. At the end of this week, a trainee will be able to handle the virtual suction tubes, and to load a hopper and to unload it through the bottom doors in the virtual environment.
- Moving on to the second shift, the junior operator will get the opportunity to load the real hopper more regularly.
- During the second period of leave, another week is spent on mastering the IMC system and its calibration. In addition, training starts for more difficult procedures like rainbowing, shore discharging and problem solving. This stage ends with a formal test for the 'junior pipe operator' certificate from a Belgian government institute.
- After only 24 weeks, then, the newcomer will be an independent dredge master with full responsibilities.
- Training continues during the third period of leave. It is extended to the entire fleet and the various vessel configurations. Thorough training is given in problem analysis and problem-solving using the IMC system.
- After two years, the training is perfected with exercises in a range of difficult operational areas such as: very long discharge lines, power distribution, the asynchronous control of suction tubes and so on. The simulator can be programmed for any of these things, and the successful pipe operator can now use the title 'senior'.

Of course, these programmes are awash with discussions, dialogues, evaluations, analyses and the search for optimal responses. It also goes without saying that Ruben De Lille and Steven Quintijn themselves regularly do a real turn on a real dredger, that Steven monitors his trainees in practice, and that there is additional on-the-job training. Even highly experienced dredge masters feel the need for additional training from time to time, either for maintaining their knowledge about control systems, or for the 'harmless' practising of specific difficult situations which they may chance across. The outcome is that the people at Jan De Nul's headquarters and the people in the field feel they are involved in a mutual learning process that ultimately improves their own, and therefore the company's, performance and competitiveness. Well-trained crews have proven their ability to deliver dredging masterpieces throughout the world (*Figure 10*).

Conclusion

The versatility of the dynamic simulators from IHC Systems with the outside 'puffin' view and their meticulous and deliberate use by Jan De Nul are a convincing demonstration: any dredging contractor of whatever size can expect excellent results from a well-designed educational programme for crew training using simulators from IHC Systems. These dynamic simulators will enhance the achievements and work satisfaction of their employees, and so boost profits at relatively low cost.

References

More information about the first generations of the Dynamic Training Simulators from IHC Systems can be found in previous issues of *Ports and Dredging*, numbers 163-166. IHC Merwede, Sliedrecht, 2005-2006