Warm good-bye to CEO Sjef van Dooremalen

In March 2006, after 35 years at the helm of IHC, Mr. J.J.C.M. van Dooremalen stepped down as CEO. He has joined the Supervisory Board of IHC Holland Merwede BV as Chairman. His farewell party was on June 19th in Rotterdam, in the historic Hulstkamp building. Many politicians, shipbuilders, dredging contractors and captains of other industries, as well as quite a few business friends from distant countries such as India and China attended. Inside the fine Jugendstil building from 1895, attention was centred on one man who has been at the centre of IHC's operations during one of the most dramatic and dynamic periods in its existence.

Mr. van Dooremalen studied naval architecture at Delft Technical University and applied for a job at IHC in 1971. His inquisitive mind was effectively employed in research jobs and his star was soon in the ascendant, without Mr. van Dooremalen paying much attention to his career. "I thoroughly enjoyed my work and rather concentrated on hydrodynamics than on managerial dynamics" he said. Yet by 1985 he found himself chaired the company at a time when Dutch shipbuilding was in the doldrums as the dredging industry suffered a severe period of overproduction. Mr. van Dooremalen’s considerable business acumen and commercial flair came just in time to save the company from the slump during which so many Dutch shipyards founndered in those bleak days.

Many speeches reflected admiration for Mr. van Dooremalen – as they should at parties like this – but there was a clear consensus about his talents: unusually adept at sniffing out a business opportunity where there is one; admirably resourceful in selling dredgers and opening doors abroad; displaying a sure touch in managing people. His ability to trust people and to let them take responsibility for carrying out their own ideas was widely acclaimed in particular. He won an impressive amount of confidence from his employees in return and undoubtedly the company thrived under Van Dooremalen’s open-minded approach.

When IHC Caland was split up into SBM Offshore NV and IHC Holland Merwede BV last year, Mr. van Dooremalen and Mr. J.D.R.A. Bax, then President and former President of IHC Caland, founded a consortium of investors who put long-term company interests above short-sighted maximum profits on shares: Rabo Participaties BV, Parkland NV and management and employees of IHC Holland Merwede. “Profits are the oxygen for a company” Mr. van Dooremalen, (who re-assumed command of the shipyards after the split) told his guests. “They are indispensable for financing research and development and for staying ahead of competitors. In the long run, this also serves the interests of shareholders best.”

For his merits as an outstanding company boss and his contribution to the Dutch industry, Mr. van Dooremalen was awarded a Royal decoration – Officer in the Order of Oranje-Nassau – that was presented to him by the State Secretary for Economic Affairs, Ms. Karien van Gennip. She also praised the departing CEO’s successes when he was president of the Dutch and European shipbuilders’ associations VNSI and CESA respectively, in drawing political attention to the shipbuilding industry’s needs.

IHC Holland Merwede has returned to sound profitability with Mr. van Dooremalen’s hand firmly on the tiller again. “The tanks are topped up, the balance sheet is free of debts, IHC is loaded to the gunwales: Govert, good luck with it,” he told his successor, Mr. G.L.M. Hamers.

Mr. Hamers, who has been managing director of Imtech Marine & Offshore since 2002 and before that was managing director of ECT’s Delta Container Terminals and President of Fokker Services, hails from an unusual background: he studied theoretical physics and econometrics at Amsterdam University. Asked whether not being a shipbuilding engineer would be a handicap, he says. “The purpose of education is to replace an empty mind with an open one, and my academic pursuits were extraordinarily well-suited for that job. In shipbuilding, it helps if you have been taught to think logically and creatively. Coming from the maritime industry with experience in maritime logistics as well as in marine installations, but not specifically coming from the shipbuilding industry, may even be an advantage for ensuring a fresh look at the way things are being done here. Furthermore, we have an excellent core of independent, highly qualified shipbuilding minds around here.” With innovation as one of the focal points of IHC Holland Merwede’s strategy, Mr. Hamers will certainly be in the right place to oversee that process.
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Cover: TSHD PALLIETER performs successfully in shallow water
Introduction
For hopper dredgers, operating in shallow waters is ‘business as usual’. It is unimportant whether shallow water operation is due to the attractiveness of a specific dredging area, or a shortcut in sailing to a disposal area: a vessel’s ability to sail in shallow waters is a necessity, in order to keep dredging profitable. Although shallow water is ‘normal’ for dredging, seamen see shallow water operations as ‘extreme’. Making the vessel’s design suitable for such circumstances is not only a realistic and understandable requirement, but also a true naval architectural challenge. Ship theories are normally based on the deep water situation. Merchant ships are designed for long voyages in deep waters, crossing seas and oceans. For such vessels, the water depth is already considered to be ‘restricted’ at 5 times the vessel’s draught. For large ships with a deep draught, the manoeuvring properties in shallow waters are investigated for the purposes of approaching and entering harbours, which will always take place at low speed. Generally speaking, tug assistance is then required. Hopper dredgers, however, are generally operated in estuaries and harbours. Neither speed reduction nor tug assistance is desired, because of their negative effect on the economics of dredging. As a consequence, these vessels must be able to operate fully independently. The properties of the hull of a dredger and its manoeuvrability must therefore be thoroughly investigated. This applies in particular to shallow water conditions, i.e. for a water depth of 1.5 or in even more extreme circumstances 1.25 times the vessel’s own draught! Attention must be paid to propulsion performance, wave generation, vibrations, manoeuvrability and course-keeping ability, squat and dynamic trim. These factors are not only important for the crew and the ship’s operators, but also for surrounding traffic.

Interpretations of ‘shallow water’
So what exactly is shallow water? The answer depends on the perspective from which it is regarded. Three interpretations of shallow water can be identified:

1. The scientific interpretation of shallow water has its origin in measurements in which the influence (as small as can be detected within the measuring accuracy) of the sea bottom was investigated, mainly for high-speed naval ships. In summary, it may be said that from a scientific viewpoint, ‘shallow’ water is defined at a water depth of approximately 10 times the draught of a modern hopper dredger, with its characteristically high breadth/draught ratio.

2. For the navigating officer of a general cargo ship, shallow water is first experienced when the speed of the vessel decreases noticeably. The speed decreases by only 0.1 knots when the water depth decreases from 10 to 5 times the draught. When water depth decreases from 5 to 3 times the draught, the speed will be reduced by another 0.5 knots! As well as this tangible drop in speed, manoeuvring properties will probably also change.

3. For the mate navigating a hopper dredger, a water depth of 2 times the draught is considered very deep. In this depth of water, the dredger can sail at maximum speed, developing its maximum propulsion power. Depending on the state of the seabed, speed will be reduced. In situations with a sandy and more or less smooth sea bottom, the dredger can develop maximum speed in water depths of as little as 1.5 times its draught. At lower levels, or in the case of a rocky sea bottom, speed must be reduced to avoid grounding (fig. 1).

The conclusion seems justified that the interpretation of ‘shallow’ water depends on one’s perception, and it is clear that the way the mate navigating a hopper dredger sees it will be considered extreme in comparison with the perceptions of the vast majority of all seamen worldwide. It should be remembered that for very
large crude oil carriers, shallow water is most likely to occur because of these vessels’ enormous draught. Such vessels must cope with very small water depth/draught ratios too, in particular when entering harbours. However, in such a situation, these vessels are moving at snail’s pace, with tug assistance. This situation, therefore, cannot be compared with the situation of a self-propelled hopper dredger operating at full power.

To illustrate the situation of the hopper dredger in normal operation, the limits of shallow water effects for such a vessel have been determined. These limits originate from the so-called backflow and wave effects, which will be explained in more detail in the following paragraph. Figure 2 demonstrates clearly that the hopper dredger can generally be found operating in extremely shallow water (fig. 2).

The effects of shallow water
Shallow water is generally experienced by speed loss and abnormal manoeuvring properties. Because the speed of a vessel is a major item in the building contract, and given the fact that most sea trials must be carried out in (more or less) shallow water, the effects of shallow water on speed have been studied on many occasions, in the past.

To carry out measurements at full scale is relatively expensive and complicated. The vessel in question must be loaded and speed runs must be carried out both with and against the current, in order to obtain valid results. To gain a complete picture, a whole range of speeds should be measured in identical circumstances, and at constant water depth. This is practically impossible to achieve and as a consequence most of the existing knowledge is based on model test results. The investigations have led to a commonly-accepted correction method which can be applied to normal speed prediction in deep water, by the ship’s designer. Model test results illustrate the difference in performance of a hopper dredger in deep and extremely shallow water, quite clearly. For a dredger with a length of approx. 130m and a breadth of approx. 27m, propulsion tests were carried out in deep and shallow water, and the results have been presented in figure 3. At maximum propulsion power, a speed of 15.85 knots was expected in deep water, and 13.7 knots in shallow water. The water depth in this case is 1.5 times the draught, resulting in a speed loss in excess of 2 knots (fig. 3).

The effects on speed are explained briefly below. Three effects can be distinguished:

1. Backflow. An important phenomenon is what is known as ‘blocking’ of the vessel when sailing in confined waters. If viewed in a cross section, the water displaced by a sailing vessel must pass the area which is reduced by the cross sectional area of the vessel itself. As a consequence, a flow arises between the sea bottom and the ship’s bottom. This is known as ‘backflow’. Depending on the ship, it may be said that the velocity of the fluid increases, causing lower pressure and higher frictional resistance. This effect is illustrated in figures 4 and 5 (fig. 4/5).

2. Increased squat. As soon as a ship accelerates, the draught will increase and the surrounding water surface will sink, due to decreasing pressure across the hull. This is known as ‘squat’. In shallow water, this effect is amplified due to the further decreased pressure as a result of the increased velocity between sea and ship bottom, as...
described above (1. Back flow). Figure 6 illustrates the pressure distribution in shallow water and its effect on the resulting keel clearance (fig. 6).

Squat can be described by two phenomena: Firstly there is a certain sinkage of the vessel due to low pressure fields along the ship’s hull at the transitions from the parallel midbody to forebody and afterbody. Secondly there is depression of the water level around the sailing vessel. The sum of these two values is covered by the term ‘squat’. From the scientific point of view, it may be interesting to separate these two phenomena, but for the captain, the only important element is the resultant keel clearance. To provide him with reliable information, full scale data is necessary, but there are certain technical implications.

- To measure the squat of a vessel is no simple task. Measurement of the keel clearance by an echo sounder is not very accurate, and will depend on the quality of the seabed. Furthermore, at very small clearances, the system does not work. Measuring the draught of a sailing ship is uncertain, due to the wave profile along the hull. If at all possible, the factor measured would not be the change in keel clearance, but only the sinkage of the vessel, without considering the fall in water surface level. A more valuable method is to make use of modern position measuring instruments such as GPS in RTK-mode, with an onshore beacon. In that case, the change in the height position of the vessel can be measured directly. However, even then, certain inaccuracies can have a negative influence on the results. After all, you must be certain of the speed of the vessel through the water measurements with and against the current must be carried out), and the actual water depth (which will depend on the tide). In short, measuring squat accurately at full scale is a complicated matter, subject to uncertainties.

- To measure the squat of a model in a towing tank is a simple task. A tumble device fitted at the bow and the stern of the model assures free movement, and the change in height can easily be measured. Tests can be carried out at different speeds and water depths, and a great deal of information can be gathered in this way. This is a very attractive method; however, the fact that the water is not ‘to scale’ affects the reliability of the results. In fact, the viscosity of the water in which the model is towed should be to scale too, but this is not the case. The question arises as to the possible influence of this scale effect on the measured model squat. In short: model-scale measurements also generate uncertain results.

Any indication is better than nothing, so model test results have been used for years to provide captains with adequate information about squatting behaviour. There are a number of general rules for...
predicting squat, based on model tests. However, for the following reasons, it transpires that these rules do not apply for hopper dredgers:

1. The squat values are predicted for the range of lower speeds. In general, vessels approach harbours or navigation channels at low speed. Hopper dredgers, however, usually sail at maximum power, and as a consequence attain maximum speed, even in shallow water since they are used to operating in these areas.

2. The shape of the hull of a hopper dredger differs considerably from that of a general cargo ship. In particular the transition from the parallel midbody to the forebody and afterbody is pronounced, based on the characteristic fullness of the dredger. As a consequence, there are large areas with low pressure below the water surface, making the extent of the squat greater than in other vessels.

3. In addition, at the pronounced transition from the parallel midbody to the forebody, a deep wave trough is created causing excessive bow trim when sailing in shallow water. For these vessels therefore, the keel clearance at the bow will determine the ship's ability to function in shallow water, rather than the clearance at the stern, as is the case for most other vessels.

These differences were important enough for a special prediction method for squat to be developed, specifically for hopper dredgers. To develop such a method, it is essential to obtain data from measurements, in order to identify the extent and tendencies of squat, and the qualifying factors. As outlined above, the only data available was from model tests, and even this data was subject to some doubt about scale effects. Nevertheless, this data was used, and a number of important conclusions could successfully be drawn, as outlined above. A series of figures are presented below in illustration of the squat effects.

Firstly, we would like to demonstrate the effect of speed on sinkage and dynamic trim. To ensure a clear view of this effect, the values shown are taken at a single water depth, so that the effects of changes in water depth do not obscure the pure effect of the speed. To clarify the effect on the trim of the vessel, the squat at bow and stern are shown separately (fig. 7).

Figure 7 very clearly shows the difference in squat at the bow and stern. Evidently, bow squat is the determining factor for minimum keel clearance. However, such information is only important for the master in shallow water conditions where, as a result of the changed hydrodynamic situation, the level of squat increases, and the keel's clearance decreases, as shown in figure 8.

Figure 8 demonstrates the importance of the bow squat in shallow water at operational speed, assuming that this speed of 13 knots can be maintained. If we assume suitable keel clearance at a water depth of 12.5m when static, at a speed of 13 knots, hardly any keel clearance remains. Here, it should be remembered that measurements at model scale are conducted in a tank with a smooth concrete bottom. In practice, the bottom may be ridged, making the risk of grounding even greater. Taking into account the variation of water depth, the hopper dredger master must be able to determine the maximum allowable speed according to the bow squat.
In addition to figure 7, a scatter plot is provided in figure 8, at a speed of 7 knots. This speed represents the situation for general cargo ships when approaching harbours or seaways with restricted water depths. The conclusion from observing these figures is that the performance of hopper dredgers is completely different from that of many other ship types, in terms of shallow water effects.

Earlier model test results on hopper dredgers, carried out over the last ten years, reveal the following trends:

- as the scatter of block coefficients (CB) on hopper dredgers is not very wide, it was not possible to identify a clear indication of the influence of the CB
- hopper dredgers with a larger Breadth/Draught (B/D) ratio seem to have greater dynamic sinkage
- hopper dredgers with a smaller Length/Breadth (L/B) ratio seem to have greater dynamic trim
- having the Longitudinal Centre of Buoyancy further forward seems to cause more trim
- optimised hulls seem to have less dynamic trim and sinkage.

From this point onwards, it is very important to investigate the full-scale situation. Full scale measurement results enable us to check the reliability of model test results, and the supposed findings. If these findings prove unreliable, we will probably be encouraged to develop a more reliable extrapolation method for application in model test measurements. At the very least, any such discovery should result in valuable data being made available to the wheelhouse of the hopper dredger.

3. Wave rise: Another clearly visible phenomenon is the rise in the bow and stern wave. As in deep water, the bow and stern wave will depend on speed, and will significantly increase the resistance of the ship (fig. 9). As can be easily recognised in figure 9, there is a remarkable difference in wave pattern. In deep water, the wave starts at the bow with a moderate wave crest whilst further downstream, the envelope is very smooth, right through to the stern. In shallow water, the pattern starts with a steep and high wave crest, followed by a deep trough. This pattern is repeated like a sine curve along the hull, further downstream. A major component of the total resistance of a dredger is the wave-making resistance; steeper waves imply higher resistance.

The most interesting question is whether or not such model test results actually reflect the full-scale situation. After all, ship owners are only truly interested in the real life situation. As a consequence, over recent years, IHC has carried out a series of measurements and observations. Producing pictures of a vessel underway, and recording qualifying data in conditions equivalent to the conditions during a model test, undertaken years previously is a difficult task. However, as shown many times, there is a good match between the ship and the model, in deep water. In addition, the model test provided some indication of the change in wave pattern, in shallow water. To further evaluate this tendency further, two pictures were taken of a hopper dredger whilst underway: one in extremely shallow water, and one in deep water, as shown in figure 10.

In these pictures, not only is the change in wave steepness clearly visible (both the bow and stern wave system), but the higher extent of wave breaking of the bow wave in shallow water can also be seen, as reflected by the white strip along the hull.

As well as these photographs, speed measurements were carried out with the same hopper dredger, in three different water depths. The correction method has been applied to the results of the speed measurement in deep water, in order to determine the expected speed in shallow water (this seemed to be reliable, based on model test experience, fig 3). As shown in figure 11, there is a major

![Comparison of wave pattern in deep (upper) and extremely shallow (lower) water at the same speed](fig. 9)

![The difference in wave pattern in deep (left) and shallow (right) water](fig. 10)
discrepancy between the results of the measurements and the results of the prediction (or the expectations based on the model tests). Obviously, model tests (on which the prediction method is based) are subject to certain scale effects. It is a known fact that model tests suffer from scale effects, because it is not possible to scale the viscosity of the water. A possible solution lies in a specific extrapolation method. Model scale values are normally extrapolated to full scale. For shallow water, however, another approach may be needed. On the other hand, it should be realised that the full-scale situation differs from the model test situation. At full scale, the sea bottom is ridged and sandy, whilst at model scale, the tank bottom is flat concrete. In assessing this observation, this difference should not be ignored.

Change in manoeuvring capabilities

It has been proved that water depth has a clear effect on the manoeuvring capabilities of a ship. The flow around and below a turning ship in shallow water differs considerably from the situation in deep water. Changes in flow direction, velocities and hull pressures have different effects on the forces on the hull, and consequently on the manoeuvring characteristics.

Hopper dredgers must remain self-supporting, even in the extreme circumstances of very small keel clearance. Thanks to their characteristically low Length/Beam ratio, hopper dredgers are generally extremely manoeuvrable. The downside is the fact that course stability is relatively low. Particularly when approaching the disposal area at idle speed (low or zero propeller pitch), keeping the vessel on course (manually) is no easy task. As you may well imagine, in a situation involving busy sea traffic, this property is particularly unwelcome.

To gain an understanding of the effect of shallow water on manoeuvrability, initial turning tests involving two hopper dredgers in several water depths were carried out. It transpired that both dredgers required less space to complete a 90° turn in shallow water, than in deep water. This finding is in contrast to the situation for tankers, a fact that makes it clear that we must maintain certain reservations in adopting individual results. Another finding was that the situation in which significant changes in manoeuvring characteristics could be detected, was at a rather restricted water depth. In these experiments, no smooth envelope was identified; instead, a more or less sudden change occurred at around a water depth/draught ratio of 2. Where the water is deeper than twice the draught, no significant changes could be detected. However, beyond that point, significant changes became noticeable.

Two cases are presented below:

Case 1: Initial turning tests. In figure 12, we show the result of initial turning tests at two water depths. An initial turning test starts with sailing at constant (full) speed on a straight course. The rudder is then suddenly set at a fixed angle, which must be kept constant until the vessel has turned through 90°. The track of the vessel is recorded (fig. 12). Only at a water depth of 11 m did a clear difference arise, as compared with the...
deep water situation. Two remarkable changes can be identified in figure 12:

1. A shorter turn was made in shallow water.
2. The turning speed (Rate of Turn = R.o.T.) in shallow water is higher.

Although a shorter turn might be seen as an advantage, it could also indicate less course stability. This is also the case when considering the higher rate of turn. Further tests with other dredgers reflected the same trend.

Case 2: To confirm these findings, several pull-out tests were carried out. During pull-out testing, the vessel is left free to find her way, with its rudders fixed at 0°, following a turning circle. The course (heading) together with the rate of turn must be recorded up to the moment they remain constant.

The conclusion that may be drawn from the measurement data is whether the vessel finds a constant course or not, thus indicating the vessel’s course stability (fig. 13). As not expected, no significant changes were identified. An initial conclusion, based on this experiment alone, could be that the effect of shallow water on course stability is negligible. Further investigation and many further full-scale trials will be needed, to make any definitive confirmation.

Vibrations and noise in shallow water

Amongst the most perceptible difficulties during operating in shallow water were (and in certain cases still are) the vibration and noise levels. Over the last few decades, much attention has been focused on these problems, and, satisfactory solutions have fortunately been found.

The combination of unfavourable flow conditions in front of the propeller and the characteristic heavy load called for the use of nozzles, combined with streamlined bodies to guide the flow from the ship’s sides to the propeller plane. This solution leads to a wake field that does have a lower axial velocity in shallow water than in deep water, but of a more homogeneous quality. In the absence of a steep wake peak, the risk of cavities on the propeller blades and of vibrations is low. Propeller pressure pulses and noise levels have been measured on a number of dredgers, both in shallow and deep water. Figure 14 shows a comparison (fig. 14).

As there is only a small discrepancy in pressure amplitude between deep and shallow water, it may be concluded that no vibration problems are likely to occur if the hull of the hopper dredger is carefully designed, even in shallow water. Since it is normal practice to take the design draught as a starting point for hull design, there is a risk that the less favourable wake field in front of the propeller when the dredger is sailing in empty condition could be forgotten. The consequence of such an error is clearly demonstrated in figure 14, by the higher level of the pressure pulses across the majority of the power range. From the point of view of vibration, therefore, the empty condition of the vessel emerges as being more important than the fact of sailing in shallow water.

The noise measurements demonstrate similar results. The table below contains a number of noise levels measured at...
the same location, on board, in deep and shallow water, whilst in loaded condition (table 1).

The presented results must be considered within the normal working situation. For shallow water, ‘normal’ should be taken to mean a water depth/draught ratio of 1.5; in practice however, lower values are possible. In such cases, the propulsion power and consequently the speed of the vessel are reduced. At that point, other comparisons should be made. Naturally, any ‘near grounding’ situation will have a considerable effect on vibration and noise levels, but generally speaking such situations are avoided.

### Table 1 - Onboard noise levels in two different water depths

<table>
<thead>
<tr>
<th>Position</th>
<th>Deep dB(A)</th>
<th>Shallow dB(A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheelhouse</td>
<td>55</td>
<td>57</td>
</tr>
<tr>
<td>Cabin</td>
<td>44</td>
<td>45</td>
</tr>
<tr>
<td>Deck workshop aft</td>
<td>81</td>
<td>84</td>
</tr>
<tr>
<td>Main engines</td>
<td>109</td>
<td>107</td>
</tr>
<tr>
<td>Steering gear room</td>
<td>94</td>
<td>95</td>
</tr>
</tbody>
</table>

**Hoswa: shallow water research**

The phenomena described above and the lack of predictability made it vital that IHC investigated these matters. When the former dredging company Ballast Ham Dredging (now Van Oord) revealed its need for usable information on the bridge of hopper dredgers, the time was obviously right to launch a joint industry research project. The dredging company Royal Boskalis and MARIN also expressed an interest in joining the research programme. Two modern hopper dredgers were selected, to be subjected to full-scale measurements: the HAM518 and the COASTWAY.

The main objective of this research project was to facilitate the design of a hopper dredger with favourable characteristics in shallow water. Based on the knowledge that model-scale values differ considerably from full-scale values, full-scale research was necessary. However, quite aside from the fact that a hopper dredger may not suffer any loss of yield during operation, full-scale research is complicated and very costly.

The research programme was therefore split into the following components:

- **A.** full-scale measurements on board two different hopper dredgers (fig. 15)
- **B.** towing tank tests with models of the same hopper dredgers
- **C.** CFD (Computational Fluid Dynamics) research to understand the physics, correlation of the model test results, development of a mathematical model and validation of that model by full-scale measurement results
- **D.** determination of a Safety Envelope based on the acquired knowledge
- **E.** reporting and recommendations.

The research programme was carried out over the last three years and was concluded in April 2006. The results have been made available to the two participating dredging companies, Van Oord and Royal Boskalis, and to MARIN and IHC. The results will now be used for designing new hopper dredgers, focusing specifically on good shallow water performance, whilst also taking account of the characteristics of propulsion and manoeuvrability. Propulsion performance tests at model scale in a shallow water basin can continue to be used in the future, thanks to a newly-developed extrapolation method, which seems to be generating more realistic figures. Furthermore, the resultant knowledge can be used to predict the manoeuvrability and squat behaviour of existing vessels. This information should prove very useful to dredger crews, in respect of safety, and grounding avoidance.

1) Measurements on a sandy bottom or a bottom covered with a layer of spoil provide uncertain indications
2) Due to limitations of the instrument
Advanced dredging system for Sri Lankan hopper dredger HANSAKAWA

In 2001, IHC delivered the 1,200m³ trailing suction hopper dredger HANSAKAWA to the Sri Lanka Ports Authority (SLPA).

The HANSAKAWA
Since it was delivered, the HANSAKAWA has mainly been deployed for maintenance dredging in the port of Colombo.
In 2005, the HANSAKAWA also intervened to assist in the recovery of the SLPA’s other dredger, the DIYA KOWULLA, which had become stranded on the quayside at the port of Galle in southern Sri Lanka, during the tsunami on 26 December 2004. During that same operation, the HANSAKAWA deepened the access channel to this small port, to allow the super-heavy lift vessel ‘Jumbo Javelin’ (1,600-tonne lift capacity) to reach the location where the DIYA KOWULLA had run aground.
For five years now, the HANSAKAWA has performed its dredging tasks to the total satisfaction of its owners, despite the fact that the vessel was originally only equipped with a very basic monitoring system. During the construction process in 2001, simple

Sri Lanka Ports Authority and the ports of Sri Lanka
The SLPA is the organisation responsible for administration and operation of the main commercial ports in Sri Lanka, currently Colombo, Galle, Trincomalee, Kankasanturai and Point Pedru.
New ports are scheduled to be developed at Hambantota and Oluvil, and both will also be administered and operated by the SLPA.
Sri Lanka’s largest major port is located in the capital city, Colombo. It, and serves as an international hub for container traffic, with a monthly average handling volume in excess of 200,000 TEU.
There are plans for major expansion of the port in the near future; this expansion will be known as ‘Colombo South Harbour’. The new harbour is planned to have four terminals, each with a length of more than 1,200m, to accommodate three berths. The depth in the new harbour will initially be 18m, but provisions will be made to allow future deepening to 23m.
The majority of other SLPA-run ports have mainly regional interests, although the port of Galle is currently also considered an auxiliary port, for the port of Colombo. In view of the development of Sri Lanka as a tourist destination, the other ports are also of considerable importance.

Mounting sensors at the intermediate
devices were installed for, to monitoring
the position of the suction pipe, the
draught of the vessel and the production
levels. However, to gain more insight into
the performance of the vessel, and to see
if a higher efficiency could be achieved in
its performance, the SLPA expressed the
wish to fit a more advanced and
extended monitoring system.

New monitoring system for the
HANSAKAWA
Whenever 'efficient dredging' becomes
an issue, IHC Systems is the partner par
excellence, and by the end of 2005, the
specialist business unit of IHC Holland
Merwede was granted the contract to
develop, build and install a new and
more elaborate monitoring system for
the HANSAKAWA. The new system will
enable the HANSAKAWA to dredge more
accurately, and to monitor the dredging
process more carefully.
The new system had to include a
number of new features, principally an
accurate monitoring system for the
horizontal position of the ship, and the
vertical position of the suction pipe.
The SLPA also requested the ability to
have all the data monitored on board
the vessel presented at a desk in the
shore-based office in Colombo.
The system now delivered to the SLPA
consists of four main elements:
1. a Real Time Kinematic (RTK) DGPS
positioning system
2. a Suction Tube Position Monitor
(STPM)
3. two Dredge Track Presentation
System (DTPS) packages
4. update interfaces for existing
instrumentation systems.

RTK is a special side-programme of
dGPS (Differential Global Positioning
System) that offers highly-enhanced
accuracy. By using RTK, the position of
the ship can be determined with an
accuracy of a few centimetres.

As part of the HANSAKAWA project, the
product supplied by IHC included a dual
RTK DGPS receiver on board the ship,
plus an RTK DGPS base to serve as a
shore reference station.
The pneumatic indicator system on
HANSAKAWA was replaced by the
electronic STPM system, which allows
the monitored data to being digitised,
and used in combination with other
recorded data on the dredger’s new
monitoring system.

Two Dredge Track Presentation System
(DTPS) packages were delivered, one to
be installed on board the dredger and
the second one at the SLPA offices,
onshore. This second package is vital to
facilitate the production of a real-time
presentation of the dredger’s activities,
at the office monitor. The shore-based
DTPS system interfaces with the
HANSAKAWA using a full-duplex radio
link. An interface was also created
between the DTPS and the dredger’s
‘production calculator’, permitting
online presentation of production both
on board and at the SLPA offices.

As part of this same project, IHC also
provided extensive training to SLPA
staff.

HANSAKAWA operational
In July 2006, the new system was fully
operational, and from that moment
onwards, the HANSAKAWA was ready to
perform its dredging tasks with even
greater efficiency than ever in the past.
The importance of the port of Colombo
is expected to increase significantly in
the future. The intended extensions will
without doubt assist the HANSAKAWA
in coping with any future challenges.
Introduction
Many problems encountered in engineering practice are often typically imprecise, non-linear, uncertain, and multi-variable. In such situations, a clear mathematical formulation of the physical process does not exist, and both classical mathematical methods and statistical methods are often less suitable, if possible at all. Artificial Neural Networks (ANN) can be an excellent tool for modelling these problems, provided that sufficient and typical data of the process is available.

ANN constitutes a class of system inspired by the biological functioning of the human brain. Over the last 15 years, ANN has been used in various fields of science and engineering, including control engineering, finance, risk analysis, pattern recognition, classification problems, predictions, etc. It has also been used in other fields including engineering geology and geotechnical engineering to model non-linear and multivariable problems such as the prediction of tunnel boring machine performance, the estimation of intact rock properties, geological mapping, constitutive models, rock mass classifications, etc.

This paper discusses the application of ANN in the field of dredging, and in particular the prediction of pump characteristics (i.e. pump head and efficiency). The ANN method was developed by MTI Holland, the R&D department of IHC Holland Merwede BV. The method employs the huge database of pump measurements collected by MTI measuring service, over the last 60 years.

The paper is organised as follows: firstly, background information about ANN is provided including the types of ANN, learning mechanisms, etc. Secondly, a brief overview is presented of the methodology developed by MTI Holland, outlining the main advantages of the method in comparison with conventional techniques. Emphasis is placed on model accuracy, and how to use the modelling framework to anticipate possible discrepancies between measured and predicted data, for each pump type. Finally, a number of other directions are provided concerning on-going research and possible future applications of ANN in combination with other techniques, aimed at tackling complex dredging operations.

Background to Artificial Neural Networks - historical and biological aspects
Research into artificial neural networks started around 1940, and was inspired by interest in the neuro-physiological foundations of the human brain. It was known at the time that the brain consists of interconnected nerve cells – the neurons – that influence each other through the transmission of electrical signals. In 1943, McCulloch & Pitts introduced a model for the functioning of a biological neuron. In 1950s and 1960s, scientists succeeded in developing the first artificial neural networks capable of learning the relationship between inputs and outputs. The synaptic links are modelled using connections of different weights, and they can be altered by a learning algorithm.

Figure 2 shows a simple mathematical model of the biological neuron described above, as proposed by McCulloch and Pitts (1943). In this model, the ith processing element computes a weighted sum of its inputs and outputs $y_i = 1$ (firing) or 0 (not firing), according to whether this weighted input sum is above or below a certain threshold. The weight represents the strength of the synapse (known as the connection or link) connecting neuron j (source) to neuron i (destination). A positive weight...
corresponds to an excitatory synapse, and a negative weight to an inhibitory synapse (Fig. 2).

In the method developed by MTI Holland for the prediction of pump characteristics, the supervised learning method was used (i.e. the back propagation algorithm) with automated regularisation. The principles of the back propagation algorithm are briefly described below.

1 Back propagation learning algorithm

The back propagation (BP) algorithm is a generalisation of the classical lowest mean square algorithm, which modifies the network weights using a gradient descent search in the weight space in order to minimise the mean square error between the desired and actual output of the network. This learning is achieved by using the steepest descent method. The BP uses supervised learning rules. In doing so, the network is trained to use data for which the input and output value are known. Once the training is completed, the network weights are frozen and the network model can be used to compute output values for unseen data.

The application of the learning rule in the BP algorithm involves two major steps:

Step 1: the input vectors are presented to the network, and propagated forward through the hidden layer(s) to the output layer. The measured output and the calculated output are compared with each other and the error signal is calculated.

Step 2: the error is propagated backwards through the network, to each hidden layer. In this way, all the weight factors can be modified by local regression techniques.

This process is repeated for every layer until the input layer is reached. Thanks to this process of propagating the error backwards through the network, the learning algorithm is often referred to as the error back propagation method.

The input-output flow of the network model is determined by the strength of the connection and the operation function of the neurons. The operation of a single neuron consists of a weighted sum of the incoming signals and the bias term, fed through an
activation function $f(\cdot)$, resulting in the output value of the neuron. This is shown mathematically as:

$$y_i = f\left(\sum_{j=1}^{m} w_{ij} f\left(\sum_{l=1}^{n} v_{lj} y_l + b_l\right) + c_i\right), \quad i = 1, \ldots, l$$

where:
- $\mathbf{u}$ is the $m \times 1$ input vector,
- $\mathbf{y}$ the $l \times 1$ output vector,
- $n$ the number of neurons in the hidden layer,
- $\mathbf{v}$ and $\mathbf{w}$ are the weight factors, and
- $b_r$ and $c_i$ the bias values of the neurons in the hidden and output layers, respectively.

### 2 Structure of ANN models

Figure 3 shows a typical architecture of an ANN model. It is composed of a number of processing elements called neurons. These neurons are interconnected with one another in a massively parallel configuration by means of weight factors. In most cases, one or more layers of neurons are considered in a feed-forward configuration.

A simple example is provided below to illustrate the application of ANN models in the field of classification problems (Figure 3).

**Example: Orange or Apple**

This simple example illustrates the use of ANN in the field of classification. The goal is to classify a fruit (e.g. apple or orange) based on three attributes: texture, shape and weight. With the available input parameters, a neural network model is built using the BP algorithm described above. The system works as follows: a piece of fruit is sent down to a belt and a classification task is conducted by the ANN model based on the three attributes, as shown in Figure 4. Using the weight, texture, and shape, the ANN model is able to determine the type of fruit on the belt and its destination (Figure 4).

### Application in dredging – prediction of pump characteristics

This section describes the methodology developed by MTI Holland to predict the characteristics of IHC centrifugal pumps (the Q-H curves and Q-η curves). The learning algorithm used in this example is the BP algorithm with network regularisation. The main objectives of the study were defined as follows:

- to develop a method that will enable us to cope with new measurements (data) in an efficient manner
- to improve the predictive capabilities of existing models
- to maintain the performance capability of the models, in the near future
- to minimise the risks involved when confronted with theoretical and measured data.

The method commonly used in practice for this kind of problem is regression analysis, more specifically polynomials and/or regression methods. Using regression analysis does engender certain disadvantages:

- less accurate predictions for high and low flow rate values
- the difficulty of incorporating categorical input parameters such as pump type into a model,
- each pump or group of pumps must be fitted to a polynomial, so large
numbers of models will be required
- less tolerant to high values, and
- extreme values in the data set.

1 Database and data analysis
The data-set used to build the prediction models originates from a large database containing pump measurements collected by MTI Holland measuring service over the last 60 years. Before constructing the ANN models, the data available was carefully screened and analysed statistically, and possible errors and extreme values were removed. Two important aspects were taken into account in the pump data analysis – the data quality and data quantity per pump type. A category number was assigned to each pump type, to distinguish between different pump types in the database. A distinction was also made between pump types with fewer measurement points, so that the accuracy of the results obtained with the new prediction models could be compared and contrasted with data quantity. Furthermore, a distinction was made between old pumps and more recently-designed pumps. In this way, the latest pump developments could be taken into account in the models. The data was analysed using conventional statistical methods, such as frequency analysis, analysis of variance, and box plots.

2 ANN method for pump prediction performance
Figure 5 shows a set up of the specially-developed pump prediction method. It consists of three main modules – the head, efficiency and NPSHr. These models are embedded in the DAS tool used by our Dredging Advisory Service office, for the calculation of pump production. The method developed makes it possible to add new pump measurements as soon as the data becomes available, thereby updating the prediction models using a self-learning mechanism. New information can also be used to expand the existing models in the future, as new pumps are designed (fig. 5).

3 ANN model structure
Figure 6 and Figure 7 show the structure of the two models developed – a QH prediction model and a η prediction model. This is a typical multi-layer feed-forward supervised neural network, as previously explained. The relationships between the input parameters (impeller diameter, impeller width, suction diameter, number of blades, speed and flow rate) and the output parameters (head and efficiency) are learned via the back propagation method, more specifically Levenberg-Marquardt training in combination with Bayesian regularisations. Regularisation was also applied to guarantee an optimum number of parameters in the models. In this way, the weights and biases of the network are assumed as being random variables, with specified distributions. The regularisation parameters are related to the unknown variances associated with these distributions, thus allowing the parameters to be estimated using statistical techniques. For more details, the reader is referred to the reference list (fig. 6/7).
Results and model validation

Figure 8 shows the overall model performance of the ANN model for the prediction of the pump manometric head in IHC’s conventional pumps. The correlation coefficient between the measured and the predicted value is $r = 0.98$. This indicates the excellent prediction capability of the model (⇒ fig. 8).

Figure 9 shows the overall model performance of the ANN model for the prediction of pump efficiency. The correlation coefficient between the measured and the predicted value is $r = 0.93$, which once again indicates high model accuracy (⇒ fig. 9).

To validate the ANN model, the results obtained were compared with theoretical calculations, determined by the Laws of Affinity:

\[
\frac{Q_2}{Q_1} = \frac{n_2}{n_1},
\]

\[
\frac{H_2}{H_1} = \left(\frac{n_2}{n_1}\right)^2
\]

where,

$H$ is the manometric head, $Q$ is the flow rate, and $n$ is the impeller speed.

Figure 10 shows the comparison between the QH characteristic computed by using the Affinity Laws, and the characteristics computed with the ANN model. By way of illustration, a random pump type was selected from the database. The ANN model was first used to compute the QH curve for a given pump, at a corresponding impeller speed (170, 228, 254 rpm). The Affinity Laws were then applied to compute the corresponding theoretical QH characteristic. As can be seen, the pump characteristic predicted using the ANN model demonstrates considerable similarity to the theoretical computations. This similarity also indicates the excellent interpolation capability of the model (⇒ fig. 10).

Conclusions

The ANN approach described in this paper would appear to be an excellent tool for the prediction of non-linear and multi-variable problems, such as the estimation of pump characteristics based on measured data. The results obtained in terms of accuracy exceed old prediction models, which are based on statistical techniques only, and open up new directions for modelling the complex and dynamic processes that are typical in dredging.

The main advantage of the ANN method presented here, as compared with statistical methods such as regression
analysis, is that using ANN makes it possible to incorporate several input parameters, including categorised data, into a single model. In addition, the model is more accurate not only close to the mean value, but also for low and high values, thus resulting in less discrepancy between measured and predicted values across the entire flow working range of the pump. The models are also fault tolerant: in other words, the presence of extreme values will not degrade the performance of the model, as occurs with classical statistical methods.

The models developed are embedded in our Trip software as used by our Dredging Advisory Service group for calculating pump performance and pump production, in different dredging conditions.

Possible directions
In current dredging operations, mainly due to the advances in the automation of modern vessels, a huge volume of data can be easily recorded. However, the data must be analysed in order to identify potential relationships between the variables involved in the process, and to construct resultant prediction models. These models could subsequently be used either online or offline for the estimation of dredging process parameters, and to assess the risks involved in the completion of a project. Typical fields in which ANN could be used in combination with other methods such as fuzzy logic and stochastic techniques include: identification of flow regimes in pipes, determination of process parameters such as soil type, critical velocity, slip ratio, and wear. ANN could also be used in typical classification problems, often encountered in the mining industry such as mineral separation and processing, etc.

References


Geijssen, G.J; C. H. van den Berg; IHC research enables dredge pumps to be designed to customers’ specifications; *Dredging and Port construction*, January 1990


The target group for this booklet is the user who is planning a new dredging vessel or is planning to renovate or adapt an existing vessel. Depending on the required head and flow, users can use the graphs in the booklet to select the best pump for their dredging task. To have the pump and bearing block correctly fitted requires specific dimensions, which are also provided in the booklet.

In addition, if they want to calculate the required foundation and hoisting capacity, the mass of the complete pump, the mass of the pump casing and the mass of the impeller, these figures are also individually available (fig. 1).

IHC pumps: the heart of the dredging challenge

Generally speaking, it may be said that to be successful, dredging contractors must adapt their fleet and technology to keep pace with market trends, or even to stay one step ahead. Based on his present fleet and market vision, a contractor may with this in mind define an operational mix for new equipment, thus avoiding the pitfalls of fleet over-capacity, over-specialisation and over-generalisation. In this context, operational mix refers to the distribution of time spent on the different types of expected maintenance and/or capital dredging operations. These operations are further typified by various factors that include the volumes and characteristics of the soil to be dredged, the dredging depths, discharge methods and ranges of sailing and pumping distances.

It is this operational mix that forms the basis for the design. A dredger designed for maintenance work in a specific harbour area will thus differ greatly from a general-purpose dredger, designed for a much broader operational mix.

The trick of the trade is to draw up the most ideal design for a given operational mix, i.e. to define the design that offers the highest economic potential. This potential is determined by the rate of production in combination with the total costs of achieving that production rate.

The cost-effectiveness of dredging today depends to a great extent on the performance of pumps; dredge pumps, submerged pumps and jet pumps, including their high efficiency versions. Aimed at the efficient transport of either the dredging mixture or water,
these are critical components in practically every type of dredging system. Their capacity has to be adapted to the task at hand, and their effective operating life in often difficult operating conditions has to be maximised. Optimum design for overall high efficiency, reducing effects of wear, and guaranteed easy repair and replacement are all key factors. In other words, upgrading pump quality to the highest possible level, and minimising overall lifetime costs.

**Pump selection**

To assist engineers not responsible for selecting pumps on a regular basis, this new booklet 'Overview of Pump range' provides an extensive introduction to the subject of selecting the correct pump. The background required for reading the tables and graphs, and selecting a specific pump, is discussed and illustrated with two examples (fig. 2).

If a pump is required with the following specifications:
- a very large ball passage
- excellent suction properties
- reasonably high efficiency
- excellent wear resistance.

The best choice would be the HR CS 1200 pump with a three-bladed impeller (fig. 4).

**Example 1**

Selecting a high efficiency pump:
If a pump is required with the following specifications:
- a duty point in water of 2.5m³/s at a manometric head of 600kPa
- the highest possible efficiency
- excellent wear resistance
- and a reasonable sphere passage.

The best choice would be the HR MD 700; both the 3 and 4-bladed impeller would fit (fig. 3).

**Example 2**

Selecting a pump with a large ball passage:
If a pump is required with the following specifications:
- a duty point of 7m³/s at a manometric head of 450kPa

The technical part of the booklet starts with two general overview graphs; one for the IHC High Efficiency pump series and one for the IHC conventional pump series. These graphs facilitate selection of the optimum pump series.

Colour-coding makes it easier to define the correct series and match the corresponding pages with the corresponding data. High Efficiency Pumps are marked in blue and Conventional Pumps in red. Depending on the selected pump series, you can thumb to the required section.

To provide greater insight into the application of a specific pump, a general description of each pump series is provided in the section relating to the pump. On subsequent pages, a performance graph for the pumps in question is presented for each pump in...
the series. Using these graphs, it is possible to define the correct pump for the required head and flow.

The table that follows provides the main dimensions and masses of the pump, the pump casing and the impeller. At the back of the booklet, the technical illustrations provide an explanation about the main dimensions in the tables.

The complete range of standard IHC pumps is dealt with in this booklet, with extensive dimensional data and masses for the main components. Both high efficiency and conventional IHC pumps are featured, ranging from low pressure versions to medium and high pressure versions.

It is however still possible that a specific application will require a pump type and/or size not covered by the pump ranges in the booklet. In that case, IHC’s in-house practical experience and technical know-how about the design, manufacture and maintenance of pumps will provide a strong basis for providing clients with good advice and, if required, delivering custom-built IHC (dredge) pumps.

The technical handbook “Overview of Pump range” is available on CD-rom. You can download it from our website www.ihcholland.com.
IHC Holland Dredgers BV and DEME signed the contract for the building construction of the MARIEKE in 2005. The construction of the vessel was subcontracted to IHC Holland Beaver Dredgers BV. The keel was laid down on 6 September 2005.

The MARIEKE is an extrapolation of the very successful 5,400m³ trailing suction hopper dredger PALLIETER that was delivered to DEME by IHC Holland Dredgers BV in 2004. The construction of the copy of the MARIEKE, the 5,600m³ REYNAERT started at the IHC yard in Kinderdijk in the summer of 2006. The launch of the REYNAERT is planned for November 2006.

The MARIEKE is a twin-screw trailing suction hopper dredger. The vessel is equipped with one suction tube with an internal diameter of 1,000mm at portside. Herewith a dredging depth of maximum 33m can be achieved. The maximum load capacity is 8,190 tons at a draught of just 7.10m. The dredged material can be discharged directly into the sea through a row of rectangular bottom doors. The load can also be discharged by means of a self-emptying system, in which the dredged soil is pumped ashore through a floating pipeline, or discharged through a spraying nozzle, so-called which is known as ‘rainbowing’. Accommodation has been provided for a crew of 14 persons.

After successful sea trials, the delivery of the MARIEKE took place in July 2006. Her first job involved the dredging, suppletion and reclamation of the beach of De Koog on the Dutch island of Texel. As this is written the naming ceremony is planned on 29 September 2006 and it will be officiated by Ms. Sophie Leterme-Haesen, wife of the Prime-Minister of the Flemish government.
Dredge simulators; an exciting tool for dredge training

Introduction
Until some 20 years ago, the job of dredging operator was learned almost entirely on the job. The knowledge of how to operate dredging equipment was passed on from generation to generation, and operators learning the trade normally gained their experience by trial and error, on real dredgers and under real operating conditions. However, with both dredgers and dredging projects becoming rapidly more complex, the awareness grew that there was a need for another kind of training facility. Furthermore, with it becoming increasingly financially important to have the dredging equipment efficiently operated at all times, the room for trial errors on real dredging projects was reduced to almost zero. It was soon recognised that the alternative would be training in a virtual environment, using simulators, a technology that was made possible by the development of computer systems, during this period. In the late nineteen seventies and early nineteen eighties, the first modest steps were taken towards the development of training simulators for the dredging industry, a process that has not ceased since that time, and that has continued to witness exponential growth in the technical possibilities available right up to the present day. Over the past 20 years, IHC Systems has played a leading role in the development of training simulators for the dredging industry.

The Basic Training Simulator
In 1977, IHC started development of automation systems for the dredgers being built by the company. In order to test these systems, computer models also had to be developed, and certain clients frequently asked whether these models could also be put to use for training purposes. In 1986, these requests led to the construction of the first cutter training simulator. The simulator was identified as ‘Basic’ and did not yet generate the complete handling capabilities and dredging process of a cutter suction dredger. The system was however able to simulate the swinging process of the dredger, allowing an operator to practise optimising the production of the dredger. Within this ‘Basic’ simulator, a computer model presented a rough approximation of the hydraulic process of the cutter suction dredger. The ‘Basic’ cutter training simulator was used for many years by the Training Institute of Dredging (TID), the department of IHC specialising in every aspect of training for the dredging industry, and it was incorporated in several of the institute’s training courses.

The Dynamic Positioning/Dynamic Tracking System (DP/DT)
The next step in the development of dredge training simulators was taken in 1996, when the DP/DT system was introduced. In order to test the performance of DP/DT systems, including time response and accuracy, IHC produced a model jointly with Imtech Marine Offshore that was capable of simulating a sailing and trailing hopper dredger. This model made it possible to position hopper dredgers, for example for unloading the hopper, and to follow predefined tracks in steering the draghead, during dredging and normal sailing, according to the DP/DT system that had to be tested. This model was also subsequently provided to dredging companies, for training their dredging crews. The model developed for the testing of DP/DT systems today constitutes the basis of the software package that is generally employed in simulators for sailing dredgers.

Tunnel Boring Machines
In 1998, IHC was involved in the development of a new special Tunnel Boring Machine (TBM) together with several contracting companies. Unlike the traditional method of tunnel boring, where prefabricated concrete tunnel segments are used to make up the tunnel, the new system was based on a continuous process consisting of pumping a cement mixture directly behind the TBM, where it could harden and create an uninterrupted concrete tunnel construction.
In line with this development, IHC developed two complicated simulation models. Firstly, a model was produced for the in situ excavation of the material by the TBM and the hydraulic transportation of the mixture of this material, using bentonite. A second model was made to simulate the hydraulic supply of the cement mixture and the process of pouring the cement behind the TBM. Although not directly related to dredging, these models represented a major step in the development of simulation models for hydraulic transport, and would subsequently prove to be of enormous significance for future models used for simulating the hydraulic process on board cutter and hopper dredgers.

**Hopper simulator for Jan De Nul**
A hopper simulator delivered in 2001 to Jan De Nul was the first dredging simulator in which IHC incorporated its experience with the development of the TBM models. The simulator was built as a precise copy of an integrated bridge, as fitted on many of the company’s modern trailing suction hopper dredgers. The simulator has advanced models of all the dredging processes involved in trailing suction hopper dredging, including:
- the excavation process with the drag head
- the hydraulic transport of the mixture from the suction pipe to the hopper
- the loading and discharging of the hopper
- pumping ashore and rainbowing.

Since hopper dredgers vary considerably in both size and configuration, the hopper simulator makes it possible to alter a large range of parameters, for all types of training situation. It is for example possible to choose between types of draghead parameters, different pipeline configurations (with the possibility of adding an extra submerged dredge pump) and between electrically or directly diesel-driven dredge pumps. The simulator for Jan De Nul was built mainly for the simulation of the dredging activities of trailing suction hopper dredgers, but it also can be interfaced with a DP/DT system to simulate the movement of the dredger. A similar unit is available at IHC Systems, which is used for training purposes and demonstrations.

**An integrated simulator in Zeebrugge**
A another major step forward in the development of simulators was taken in December 2004, when a new integrated bridge simulator was opened at the Centre for Maritime Education in Zeebrugge, Belgium. This training simulator is intended for training the navigational skills of officers, on a large variety of vessels. As well as normal, free-sailing ships, in which only the hull interacts with the sea water, it is also possible to give training in the navigation of hopper dredgers and fishing vessels. These two latter examples are very specific, since these types of ship can have their suction pipes or their fishing...
nets respectively interact with the water and the seabed, creating an extra level of difficulty for the navigating officer. To make it possible to train for the specific situations on board hopper dredgers, IHC has provided the simulator with an elaborate model, including all the relevant dredging parameters. The importance of this simulator for the dredging industry lies in the fact that it is the first in the world in which the navigation and the dredging aspects of a hopper dredger have been combined. The Zeebrugge simulator is currently being used by several Belgian maritime organisations, educational facilities and the two leading dredging companies, DEME (Dredging, Environment and Maritime Engineering N.V.) and Jan De Nul. Hopper dredgers with hopper capacities ranging from 5,000m$^3$ to 16,000m$^3$ can be simulated, in Zeebrugge.

A cutter simulator for DEME

Once the Belgian DEME group had issued the order to IHC Holland Merwede, in 2004, to build the new and revolutionary heavy duty cutter suction dredger D’ARTAGNAN, it was not long before they took the decision to have a cutter simulator built as well, that would enable the company to train the operators of this kind of dredger. DEME expressed the wish to acquire a simulator focused mainly on cutting and the hydraulic processes. To simulate the cutting processes and mixture forming and spill at the cutter head, a complex model of the breaching of the ground in front of the cutter was developed. This model was developed in close cooperation with DEME by IHC Systems and MTI Holland. It makes it possible to adapt the parameters of material to be dredged on a 10 x 10cm grid. The hydraulic model of the cutter simulator is based mainly on the earlier hopper simulators. The new feature of this simulator, in comparison with the first ‘Basic’ cutter simulator back in 1986, is the models that simulate most of the secondary systems on board a cutter suction dredger, including spuds, anchors, anchor booms and winches. DEME’s cutter simulator was installed in September 2005 at the Group’s brand-new training centre in Lambersart near Lille, in Northern France, and was christened the ‘Constance Bonacieux’. The system is able to simulate almost all the cutter suction dredgers in the DEME dredging fleet, with the exception of the D’ARTAGNAN. These vessels include the AL MAHAAR, the RUBENS, the VLAANDEREN XI and the VLAANDEREN XIX; in addition, a standard IHC dredger of the type Beaver 6518 has been added to the facilities. The ‘Constance Bonacieux’ has now been part of DEME’s training facilities for several months, and trainees have suggested on numerous occasions that the simulations are so realistic, that they often forget they are not on board a real dredger.

A cutter simulator for Jan De Nul

The development of cutter simulators is still continuing, and IHC Systems delivered a new simulator for the Belgian dredging group Jan De Nul as recently as 2006. This new simulator includes the same features as its predecessors, but also offers far more elaborate ‘outside’ image facilities, including the presentation of 3-dimensional objects. This new ‘outside’ image was developed entirely by IHC Systems, and amongst the realistic images it displays will be the breaching of the material to be dredged, both above and below the water. This feature will allow the user of the simulator to actually view the behaviour of the ground in front of the dredger as a result of the cutting, spud carrier performance and swinging motion. To achieve this imaging, the model required to simulate the composition of the ground to be dredged will be the most complex and advanced currently available. Another new aspect of the simulator for Jan De Nul, is the possibility of simulating the impact of sea and ocean waves on the hull of the dredger, and the subsequent response of the vessel. This latest simulator went into service in July.

TID’s Beaver cutter suction dredger simulator

Based on the technology described above, IHC also constructed a dredge simulator based on an IHC Beaver dredger, for TID. This simulator contains all the latest features, and it was installed in early 2006 at the TID premises in Kinderdijk. Since that time, the simulator has successfully been used for a number of training sessions.
## ON ORDER

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<td>China</td>
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<td>WHEEL SUCTION DREDGER - Custom-Built</td>
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<tr>
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<td>DELTA SHIPYARD</td>
<td>11018</td>
<td>Delta Multi Purpose</td>
<td>The Netherlands</td>
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<tr>
<td></td>
<td>11019</td>
<td>Pusher Tug 2500</td>
<td>Kazakhstan</td>
</tr>
<tr>
<td></td>
<td>11020</td>
<td>DMPT 3000</td>
<td>Kazakhstan</td>
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<tr>
<td></td>
<td>11021</td>
<td>DMPT 3000</td>
<td>Kazakhstan</td>
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*[Artist’s impression of the 11,650m³ TSHD ordered by DEME (CO 1246)]*
## Recently Delivered

<table>
<thead>
<tr>
<th>Type</th>
<th>Yard No. / Name</th>
<th>Specifications</th>
<th>Country</th>
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<tbody>
<tr>
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<td>CO1243 MARIEKE</td>
<td>5,600m³</td>
<td>Belgium</td>
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<td><strong>CUTTER SUCTION DREDGER</strong></td>
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<td>02391 Beaver 600</td>
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<td>02425 Beaver 1200</td>
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<td>Nigeria</td>
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<td>02426 Beaver 1200</td>
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<td>02406 Beaver 1600</td>
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<td>U.A.E</td>
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<td>02433 Booster Station 1,686kW</td>
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<tr>
<td>11016 Delta Multi Purpose</td>
<td></td>
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<td>The Netherland</td>
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<tr>
<td>11017 Delta Multi Purpose</td>
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<td>The Netherland</td>
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</table>

*The MARIEKE at IHC's yard in Sliedrecht*
Delta Multi Purpose Pusher Tug 2500 (11016) SMIT BRONCO

The MARIEKE on her way to sea trials
First job of the MARIEKE by Texel (The Netherlands) August 2006
# MARIEKE

5,600m³ trailing suction hopper dredger

<table>
<thead>
<tr>
<th><strong>PRINCIPAL CHARACTERISTICS</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>MARIEKE</td>
</tr>
<tr>
<td>Type</td>
<td>trailing suction hopper dredger</td>
</tr>
<tr>
<td>Client</td>
<td>DEME Belgium</td>
</tr>
<tr>
<td>Builder</td>
<td>IHC Holland Dredgers BV/ IHC Holland Beaver Dredgers BV</td>
</tr>
<tr>
<td>Length overall, approx.</td>
<td>97.50m</td>
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<tr>
<td>Length between perpendiculars</td>
<td>84.95m</td>
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<tr>
<td>Beam</td>
<td>21.60m</td>
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<tr>
<td>Draught at maximum load</td>
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<tr>
<td>Hopper capacity</td>
<td>5,600m³</td>
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<tr>
<td>Diameter suction tube</td>
<td>1,000mm</td>
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<tr>
<td>Maximum dredging depth</td>
<td>33m</td>
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<tr>
<td>Total installed power</td>
<td>6,776kW</td>
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<tr>
<td>Loaded speed</td>
<td>12.8 knots</td>
</tr>
<tr>
<td>Accommodation</td>
<td>14 persons</td>
</tr>
</tbody>
</table>
Ports and Dredging is published by IHC Holland with the aim of keeping the dredging industry informed about new developments in dredging technology, vessels and other items of dredging equipment delivered, and the experiences of users all over the world.

IHC Holland develops and applies new techniques. These are manifested in a range of advanced products and services: custom-built and standardised dredgers, dredging installations and components, instruments and automatic control systems, engineering and consultancy, research and development, renovation, operator training and after-sales service. IHC Holland provides optimum solutions for the problems faced by the dredging and alluvial mining industries.