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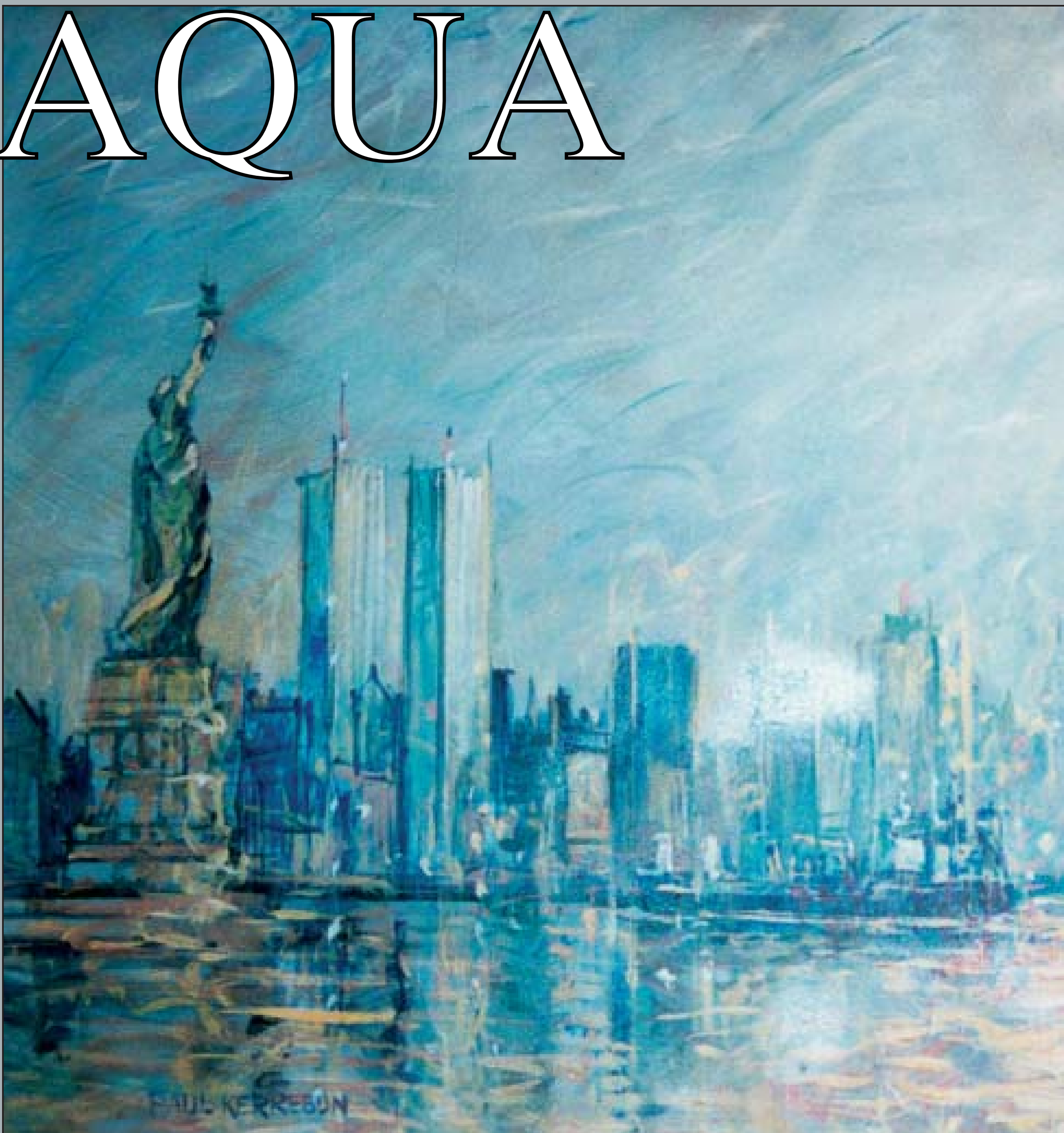
TERRA ET AQUA



INTERNATIONAL ASSOCIATION OF DREDGING COMPANIES

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Front cover:
This "surrealistic" painting depicts international dredging ships at work in New York Harbour, a situation which is presently forbidden by US law. The painting was created by Paul Kerrebijn at the IADC exhibition booth during WODCON XV in Las Vegas, Nevada (see page 10).

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International Association of Dredging Companies

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TERRA ET AQUA

Editorial

Looking towards "Dredging into the 21st Century", as participants and speakers at WODCON XV tried to do, the articles in this issue of *Terra et Aqua* present an indication of where dredging technologies may be heading in the future.

Environmental issues remain the buzz word for this decade, but balancing this with the financial consequences of large infrastructure projects is important. Economic *versus* environment has become economics *and* environment. Cooperation amongst dredgers, policy makers, and the public has resulted in large investments of time and money by dredging companies and related industries into research and development. In one of our articles some of these innovations, new ways of surveying and monitoring dredging activities, have been concretised into an "ideal" ship — a dredger's dream of a multi-tasking and versatile survey vessel (page 5).

In addition, the Dredging Operations and Environmental Research (DOER) programme of the USACE, which was presented at the WODCON, is reviewed here. It is designed to be a ten-year plan focussed on specific applied research in six pertinent dredging areas.

On the side of economics, another recently developed – and still developing – technology described here is a data acquisition system for measuring the hopper discharge process. Providing a reliable system for measuring hopper operations results in considerable savings in labour, which results in more cost-efficient dredging. This system is already installed on some of the largest trailing hopper suction dredgers operating today.

Perhaps one of the most challenging issues for dredging in the next century is the necessity for the dredging industry to communicate with a broader world. As was characterised at the WODCON, dredgers tend to "preach to the converted", leaving a wide gap between the positive results of dredging and the public's perception. With so much money being spent on research and so much excellent technology being developed, shouldn't we spend some thought on how we can get this information to the world beyond our own dredging conventions?

Marsha R. Cohen
Editor

K. van Craenenbroeck, J. Duthoo, M. Vandecasteele, J.A. Eygenraam and J. Van Oostveen

Application of Modern Survey Techniques in Today's Dredging Practice

Abstract

Because of the growing demands of public and private clients the dredging industry has developed means for measuring the performance of dredging equipment. These instruments measure aspects such as production, accuracy, efficiency and environmental safety. The performance then has to be maximised as a function of the dredging task, be it capital or maintenance dredging.
The monitoring of dredging works can be done by a whole range of survey techniques, on board both dredgers and survey vessels, including multibeam echosounding, in-situ density profilers, positioning systems, as well as specialised environmental monitoring devices. The most recent developments are reviewed here.

Introduction

Survey activities to monitor water works are probably as old as the practice of dredging itself. From milestones such as the first floating grab (driven by "human-feet-power") to the launching of hopper dredgers, super-cutters and jumbo trailers, operators as well as clients have wanted and needed to know the progress and the results of their activities.
Because demands of public and private clients continue to grow, the performance of dredging equipment – production, accuracy, efficiency – has to be maximised as a function of the dredging task, whether it is capital or maintenance dredging: harbour construction, shore protection, the navigability of fairways and harbours, offshore trenching, and pre-sweeping.
The monitoring of these works is done by a whole range of survey techniques, on board both dredgers and survey vessels. The present paper reviews some of the survey and monitoring techniques commonly used today, such as multibeam echosounding, in-situ density profilers, positioning systems, and environmental monitoring systems.
A multi-tasking and versatile survey tool might look like the vessel depicted in Figure 1. Although most surveyors of the world only dream of it, this "ideal" vessel can be used as a guide through this paper.

Multibeam Echosounding

Working principle

As is the case with the commonly used single-beam echosounders, multibeam echosounders also use short acoustic transmission pulses to scan the seabed.
Each seabed element produces its own echo which is received at the receiving part of the acoustic transducers. These echoes, together with sound travelling time and other system parameters, are processed into calculations of angle between the element on the seabed and the transducer normal. In this way the horizontal distance and depth to each seabed element can be calculated.

Experience

Several multibeam echosounding systems have found their way to the international dredging community, not only as a valid pre- and post-dredging survey tool, but also as an on-line monitoring device on board (trailing) dredgers.

From a survey vessel

Multibeam echosounding data allow the production of detailed progress reports and to make accurate volume calculations. For example, this new survey system has been successfully used during the Interconnector pipeline project (Bacton, UK to Zeebrugge, Belgium), where a trench had to be dredged through the access channels "Scheur" and "Wielingen" to Antwerp and nearshore close to the landfall.

With multibeam echosounding on board the survey vessel *Oostende XI*, where the transducers are mounted in the bow of the ship (Figure 2), lines were surveyed parallel to the axis of the pipe. The trench, 10 metres wide and with slopes 1 in 9, was 100% covered by the echosounders in a couple of runs, depending on the water depth. Dredging activities were monitored on a daily basis. Once the trench was

Karel van Craenenbroeck

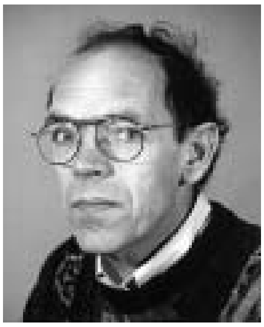
Karel van Craenenbroeck graduated as a geologist in 1985 and joined Overseas Decloedt as part of the R&D team developing the Navitracker density probe. Since 1987, he has been involved with treatment and disposal of contaminated sediments and environmental monitoring, and in 1991 he became project manager with Silt NV in this area.

J. Duthoo

Since 1978 J. Duthoo has been involved as electronic engineer on hydrographic and shore-based systems during the expansion of the Zeebrugge Harbour. In 1985, he moved to Overseas Decloedt as senior service engineer. In 1991 he joined Silt NV as head of the electronic department, where he is responsible for the technical aspects of the hydrographic systems and environmental monitoring systems.

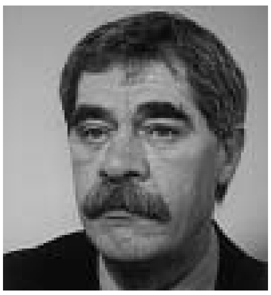
M. Vandecasteele

M. Vandecasteele started 25 years ago as member of one of the study teams for the extension of Zeebrugge Harbour. He then worked as surveyor in the hydrographic department of Silt NV. He became survey manager of the hydrographic department of Silt N.V. and is now based at Zeebrugge where he is responsible for the execution of all the environmental and hydrographic surveys.



Jan A. Eygenraam

Jan A. Eygenraam graduated from Delft University of Technology, The Netherlands in 1974 with a MSc in Mechanical Engineering (Dredging Technology). He started his career as a research engineer with Zanen Verstoep NV. Since 1988 he has been manager Dredging Development, Survey and Fleet Automation at Baggermaatschappij Boskalis BV.



J. Van Oostveen

J. Van Oostveen holds a BSc in Electronic Engineering and has been involved in hydrographic surveying from 1969 as an officer (RNR) of the Hydrographic Service of the Royal Dutch Navy. Until 1988 he was employed in the hydrographic department of Delft Hydraulics in various functions. Since 1988 he is manager of the Survey Department of HAM.

dredged to the theoretical profile, the pipelaying started. Afterwards, the backfilling with gravel took place. With the multibeam echosounder, the progress of the backfilling could be observed clearly, which enabled the daily re-definition of the backfilling areas.

Another application of accurate observations of dredging operations is found in the “unveiling” of wrecks.

On board dredgers

Multibeam echosounders can also be used on the dredgers themselves, especially on trailer dredgers. When a multibeam system is built into the bow of the vessel, or mounted in the bottom, the wide coverage of the multibeam makes it possible to “view” the seabed accurately on both sides of the dredger. Making use of dedicated software, the cross-profiles of the seabed, can be shown on the computer three-dimensionally as the dredger moves forward.
This enables the crew to anticipate and optimise the dredging, while bathymetric surveys can be carried out at the same time.

One of the newest super trailing suction hopper dredgers *WD Fairway* is equipped with a dual head Simrad EM3000 multibeam echosounder. Two multibeam transducers are mounted in the bottom of the vessel. The vessel has been operating on a few offshore projects on the North Sea during the past year. During the Gannet Project for Shell UK Exploration and Production several pipeline bundles had to be covered by sand for insulation purposes over a length of approximately 12 km. Prior to the dumping operations a pre-survey was carried out by the *WD Fairway* using one of the multibeam transducers. Owing to the depth of the location – 95 metres – a single run over the centerline of the bundles was sufficient to cover more than the width of the sandberm to be dumped.

After each trip of approximately 17,500 m^3 of sand an intermediate survey was carried out, again by sailing one single run over the centerline of the bundle under construction. The results of these intermediate surveys were processed during sailing to and from the win area. Before arrival in the field the latest situation was known and the next dump location prepared.

The advantages of surveying with the trailing suction hopper dredger instead of surveying with a separate offshore survey vessel are:

– no additional costs for an offshore survey vessel;
– fewer survey crew members are needed; and
– there is no date transfer between survey vessel and dredger.

On the next project of the TSHD *WD Fairway*, a pre-sweep job for ELF Exploration UK Plc. in the Elgin/Franklin Field, the multibeam echosounder on board the vessel proved again to be very efficient.

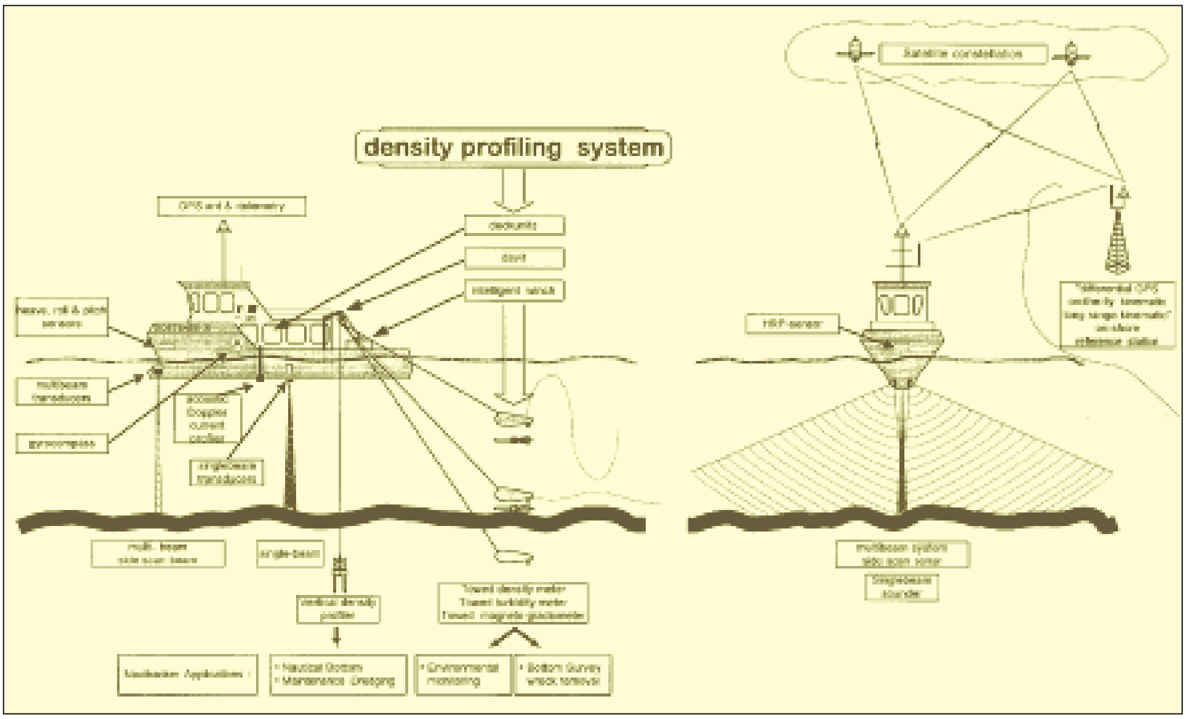


Figure 1. Survey vessels and systems: general application programme.

First of all, a pre-dredge survey was carried out over the sandwaves to be dredged. In between dredging and dumping intermediate surveys were carried out over the centerline of the pipeline route, causing hardly any delay in the dredging cycles of the dredger. The results of the multibeam echosounder surveys were handed over to the client for stress analysis.

Another possibility is to mount a multibeam on the suction pipe(s) of a trailer dredger. *Geopotes 14* and *HAM 310* have both in the past years on a number of occasions been provided with such an installation of multibeam and motion sensor mounted together on one of the pipes. When dredging trenches, doing pre-sweeping but also when covering and uncovering e.g. pipelines, the multibeam will give full survey capabilities to the dredger. It will yield accurate steerage information for the vessel and at the same time show results achieved the last run. In order to obtain in- and out-survey data only, an additional run will have to be made by the dredger over the theoretical line at the start and at the end of the work. In this way all control stays on board the dredger and no (costly) additional survey vessel, with transfer of data to the dredger and back, is necessary.

Figure 2. Multibeam transducers mounted in the bow of the survey vessel Oostende XI. *This system is fixed. Mobile systems are also commonly available.*

In-situ Density Profilers

During the last decades, the presence of loosely packed silt layers in maritime access channels and harbours has caused the responsible authorities severe problems in trying to determine and maintain their Port Operations Policy and Maintenance Dredging Strategy. Owing to the presence of this "fluid mud", traditional acoustic hydrographic survey methods are insufficient. This fluid mud results in unpredictable changes in the registered depth which is mainly caused by hydro-meteorological conditions and seasonal variations. This also hampers a correct monitoring of maintenance and capital dredging work in these areas.

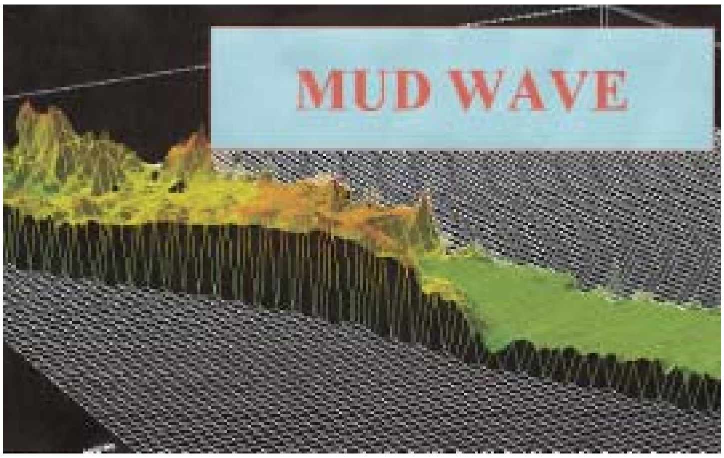


Figure 3. In fluid mud areas, deep-draughted vessels sail above a clearly defined physical (density) level within the fluid mud body. Although an internal wave is observed at the sediment-water interface, safe navigation is not hampered and is guaranteed by the navigable depth concept.

To allow deep-draughted vessels to enter these ports under adverse "mud" conditions and to optimise the use of the maintenance dredging budget, the concept of the navigable depth in muddy areas has been developed. The navigable depth corresponds with a physical level within the fluid mud layer indicating a safe navigation limit for deep-draughted vessels. Extensive laboratory research, real scale sailing tests and modelling work was done in order to observe the behaviour of ships sailing above and within the mud. Based on this, many ports established a safe navigation limit as a density level within the fluid mud (Figure 3). Because of the different physical properties of the mud, this level has to be established for each port individually.
In Rotterdam (The Netherlands), for example, the depth of the 1.2 t/m^3 density level has been established as the navigable depth, whereas in Zeebrugge (Belgium), the 1.15 t/m^3 density level is considered a safe limit for navigation.

For the in-situ measurement of these density levels, several types of density gauges have been developed. The first of these to measure continuously was the towed density probe "Navitracker".

"Navitracker": Basic system
The basic Navitracker system was originally designed to track automatically a pre-determined density level within the fluid mud in order to allow the production of navigable depth charts on the basis of sufficient data, comparable with the quantity of data collected during a traditional acoustic survey.

The basic Navitracker system consists of:
– a hydrodynamically balanced streamlined towfish with built-in scintillation-type transmission gauge, pressure sensor and relocation transponder;

Figure 4. The Navitracker survey system as installed on board the RWS survey vessel Octans.

– a computer-controlled "intelligent" survey winch; and
– the deck equipment, including density calculation unit, filtering and conditioning unit, 4 channel pen recorder and the control computer with Trackersoft software

The measured density data are gathered by the control computer and sent to the survey computer.
These measurements are integrated with other survey data such as X,Y,Z -position, echosounder information, heave systems, and so on.

Basic system operation
The Navitracker system is used daily in Rotterdam, Zeebrugge and Emden (Figure 4). The winch control computer of the system controls the towfish depth by paying out or hauling the tow cable. The cable speed can be set from 0 to a maximum of 50 cm/s (typical 20 cm/sec) with a maximum acceleration of 50 cm/s^2.

The Trackersoft software of the control computer monitors the sensor acquisition from the towfish, controls the winch, and the survey computer communication. This allows six operating modes:
1. vertical profile mode, in which case the towfish is used to measure stationary density profiles
2. horizontal undulation of towfish at constant speed between two depths or density levels (e.g. 15 to 17 m or 1.15 to 1.20 t/m^3)

Maximum depth can be a set 210 kc - echosounder depth minus a presettable offset
(e.g. 12 m top layer - 1 m above top layer)

3. horizontal tracking of the towfish at fixed or variable speeds:
   a. on a fixed depth, e.g. 17 m
   b. on a fixed density layer, e.g. 1.15 t/m3
   c. on the base of paid-out cable length, e.g. 20 m
   d. on the base of 210 kc echosounder minus an offset, e.g. 15 m - 1 m = 14 m.

Basic system output
Charts produced are nautical charts, indicating the position of the navigable depth compared to the official reference level (Figure 5).

Upgrades
The original Navitracker towfish was designed to be towed within a fluid mud layer to obtain as much data as possible of a pre-determined density level to allow the production of reliable nautical charts on the basis of a huge amount of data. However, to be able to study the composition, the structure and the behaviour of a fluid mudbody, it is necessary to collect data throughout the mud column. Because of its shape, the towed body only penetrates in mud with a density up to 1.3 t/m3. To allow the collection of data in more consolidated material, an H-shaped inclinometer-equipped Vertical Density Profiler was added to the basic system. This VDP is fully compatible with the existing towfish, towcable and electronics.

Another high accuracy VDP silt density profiling probe (Figure 6) was developed by the Dutch companies TNO Applied Physics and Seabed Systems in cooperation with dredging companies Boskalis and Van Oord ACZ, Rijkswaterstaat Directorate South Holland and the Port of Rotterdam.

Unlike the Navitracker gauge, where a Cs 137 radioactive source is in use, density measurments are based on the absorption by the fluid mud of gamma rays as radiated by a small Barium 133 source. This Barium source is placed in an H-shaped frame opposite to a so-called "Scintillation detector", a highly sensitive gamma ray detector. This type of detector gives a quantitative analyses of the amount of gammas passing through the medium, but it also allows the possibility of producing a spectral image which gives an indication of the physical properties. For optimum safety the Barium source is of a relatively low activity and when the system is not measuring the source is fully encapsulated in a special gamma absorbing material.
The resulting level of radio activity on the surface of the probe housing is very low and when handled with normal care it will impose no risk to the health of the operator.
Besides these density measurements the probe also has sensors for the measurement of tilt in both

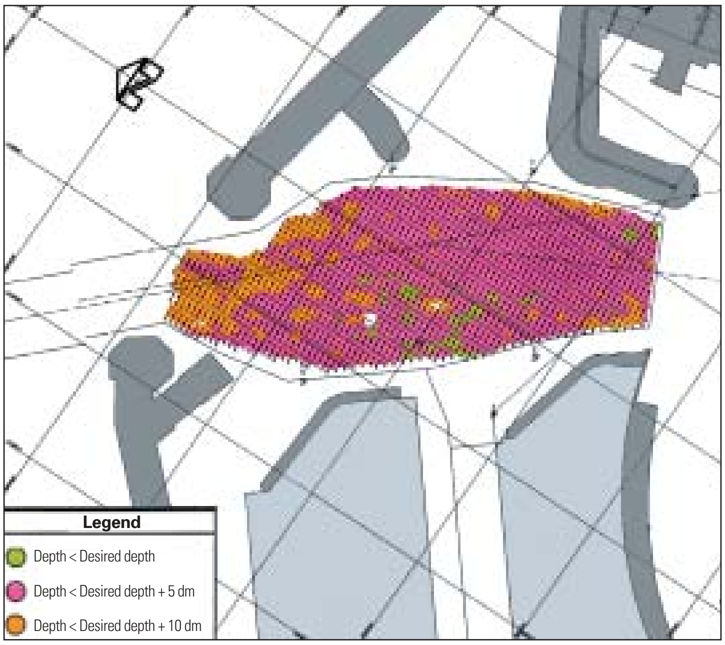


Figure 5. Chart indicating the navigable depth in the Port of Zeebrugge.

Figure 6. The vertical density profiler D2ART.

Figure 7. Positioning system of the disc bottom cutter dredger De Vecht during dredging trials at Lake Ketelmeer.

directions, pressure, temperature and conductivity. Although these parameters are primarily used for the accurate calculation of the depth of the sensor, they are also available for further analyses.
The data acquisition and control programme takes care of the fully automated measuring procedure.

A complete D2ART silt density measuring system consists of three main components:
– the nuclear probe;
– a data acquisition and interfacing computer that controls the fully automated measuring process, acquires the probe data and interfaces to the ships echosounder and navigation system; and
– a computer-controlled winch that holds up to 80 metres of tow/signal cable.

It is anticipated that the type of supporting (towed) bodies used to execute density measurements, will become Christmas trees, carrying various sensors, samplers and measurement devices for all types of monitoring operations (see below).

Positioning

Simultaneously with the accuracy of sounding devices, the performances of positioning systems have strongly increased. To achieve this, not even the sky was the limit.

Whereas two decades ago dredge operators and clients were satisfied with range-range and (pseudo-) hyperbolic positioning systems such as Mini-Ranger, Trisponder and Syledis and went wild with the introduction of more accurate systems such as MicroFix, Axyle and laser-beam- based systems (Navitrack 1000 and Polarfix), these days, many of them can already be found in the antique shop.

When the cold war ended, satellites were soon used to support global positioning systems for the industry, who quickly improved it to differential global positioning systems, which was then followed by enhanced differential GPS. Nowadays, on-the-fly kinematic and the introduction of long-range kinematic techniques complete the inauguration of a new era in positioning.

Together with the important increase of the accuracy of positioning systems for vessels, the accuracy of the positioning of the sediment-removal tools – dragheads, cutters, backhoes – increased drastically and was even more improved by the development of systems to monitor on-line the position of the removal tools with regard to the sediment. This is of particular importance when performing trench dredging or when removing contaminated sediments.

During the test dredging operations at Lake Ketelmeer, the positioning of the dredgers were based on dGPS-KART and dGPS-Trimble systems, combined with ladder angle, pressure sensors and tide gauges.

A particular positioning system was developed for the disc bottom cutter *de Vecht*, where a high frequency echo-sounding system was mounted in an acoustic mirror mode at both sides of the disc cutter (Figure 7). This acoustic mirror enables the dredger to avoid problems related to gas bubbles and turbidity caused by the removal of the sediments.

Environmental Monitoring

During the last few years, a new task has been addressed to the survey departments of dredging companies: environmental monitoring. Current and wave monitoring already were part of the tasks, although in very specific cases. Now, these measurements have become common practice, together with turbidity- and water-quality measurements and sediment transport analysis. The works that boosted these types of survey and monitoring are undoubtedly the works performed in Hong Kong and for Øresund/ Storebaelt. There is inevitably a growing demand from clients to offer these monitoring services.

Especially for environmentally sensitive works (and which aren't nowadays?) these types of measurements appear in tender documents. In most cases, two types of measurements are required:
- stationary measurements, done from a measurement platform; and
- continuous underway measurements, operated from a survey vessel.

Stationary measurements platforms mainly contain:
- a datalogging system (self contained or direct reading);
- turbidity measurements at selected depths (optical transmission or backscatter);
- current measurements (mechanical or electromagnetic);
- conductivity and salinity; and
- temperature.

Vessel-mounted systems generally include:
- turbidity measurements;
- CTD measurements; and
- water sampling devices.

These measurements are generally integrated with acoustic Doppler current profilers, in order to achieve an idea of the mass transport of particles in suspension generated by the dredging operations. Following the development of the VDPs (see above), the devices were adapted to be used for horizontal towing purposes in the water column..

Both the profiler/towfish and the acquisition software can be adapted to support additional sensors on board. This enables the continuous profiling of the water column, in order to monitor turbidity, salinity and temperature. Currently, environmental monitoring operations of that type are done on a regular basis in Zeebrugge Harbour (Figure 8).

Final upgrades of the monitoring bodies so far are the integration of in-situ particle size profilers and tri-axial magnetometers with the towed bodies. Tests on the River Schelde proved that the processing performance of the magnetometer measurements shows significant increases by towing the instruments close to the seabed (higher signal returns, less influence of vessel traffic).

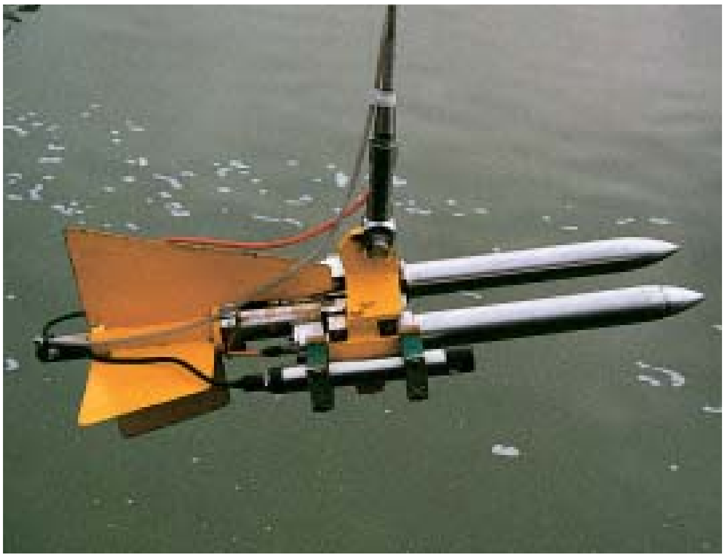


Figure 8. Optical sensors mounted on the Navitracker VDP, for the environmental monitoring (turbidity, salinity, temperature) of the water column during dredging and relocation operations.

Thanks to the development of towed bodies and measuring vehicles as described above, this is no longer wishful thinking but the next logic step in the environmental monitoring of dredging operations.

Conclusion

During the past five years, both dredging and survey technology have developed rapidly. Positioning as well as specific monitoring techniques have made major strides. Many techniques – especially positioning and acoustic survey systems – are improving very quickly. These techniques include:
- the multibeam echosounders on board survey vessels or mounted on board dredgers;
- density profilers such as the Navitracker;
- Vertical Density Profilers (VDP) such as D^2ART; and
- differential global positioning systems (dGPS).

Along with the other improvements in the dredging industry, survey departments have been contributing their share in the implementation of modern technology and concepts in the monitoring of dredging operations. Especially environmental monitoring has received and continues to receive increased attention.

WODCON XV: Dredging into the 21st Century

Las Vegas, Nevada USA
June 28-July 2, 1998

Every three years the worldwide dredging community gathers together to exchange information about their activities, projects and research. The World Dredging Association (WODA), comprising the Central Dredging Association (CEDA), the Eastern Dredging Association (EADA) and the Western Dredging Association (WEDA), take this opportunity to present papers, compare notes and talk in the corridors about the state of the art of dredging worldwide.

Gathering at the IADC booth (from left to right), Ms Constance Hunt from the World Wildlife Fund in Washington DC, Mr Peter Hamburger of the IADC, and Dr Joseph Westphal, US Assistant Secretary of the Army for Civil Works.

This year, the 15th World Dredging Conference, organised by the WEDA under the supervision of Lawrence M. Patella, WEDA Executive Director, took place in Las Vegas. During the opening ceremony, Albert J. Savage III, Chair of the WODA Board of Directors, as well as Robert Hopman, WEDA President, Brian Wheeler CEDA President, and M. Simaputang, EADA Chairman, welcomed some 480 delegates who hailed not only from all over the USA and Canada, but also from the UK, The Netherlands, Belgium, Brazil, Japan, Saudi Arabia, South Africa, Malaysia, and Australia to name a few countries. A wide range of professionals including shipbuilders, port authorities, private dredgers and public agencies, universities and researchers were represented.

The conference provided attendees with four full days, packed with more than 100 presentations, and innumerable intensive discussions with colleagues. The papers have been published in a two-volume proceedings available from the WEDA. In addition, 55 companies had booths in the exhibition hall where further information could be gained about high-tech dredging capabilities and specific projects.

WODA Environmental Day

For the first time, one entire day was especially devoted to the issues in and around dredging and the environment. It was a unique forum introduced by Craig Vogt, who chairs the WEDA Environmental Commission. Obviously, a dredging project involves many diverse groups, which demands inter-active communication that extends beyond the specialised domain of engineers and dredgers. This is too often under-utilised. For that reason, representatives of environmental groups – the Royal Society for Protection of Birds and the World Wildlife Federation – were also invited to offer their different but essential perspectives on dredging activities.

Peter Hamburger, Secretary General of the IADC, acting as a member of the PIANC-PEC, gave a response to the environmentalists by addressing the public relations aspects of dredging. In this context, he called for a "new spirit of cooperation", recalling that in "the old picture...dredgers were the bad guys. Port authorities were the bad guys. And of course environmentalists were the good guys". This is clearly indicative of a failure of the dredging industry to communicate and it has perpetuated these misconceptions. "We have been preaching to the converted, talking to our colleagues and receiving positive feedback...but we have forgotten about other target groups...the politicians, policy makers, environmentalists, the opinion shapers, the general public".
His proposal, which is being considered by the PIANC, CEDA, and other related organisations, is to form "a joint communication framework" – a public relations effort to "reach out" beyond the inner circle of the dredging industry to "better inform,... to educate" the media and the public "that dredgers offer solutions to environmental problems, that we do not create these problems".

Paul Kerrebijn at work at the IADC booth during the WODCON.

The presentations given during this special session will be published in a separate volume. In addition, the WODA Board used the occasion of the conference to adopt an official policy on the environment (see box, following page).

During the luncheon on this First Environmental Day several other interesting events took place. Dr Joseph Westphal, the newly appointed US Assistant Secretary of the Army for Civil Works, gave the keynote address. His enthusiasm and support of dredging as well as his interest in reaching beyond the US to learn about international dredging experiences was very welcome.

Then came the drawing for an original painting by Paul Kerrebijn, an artist known for his accurate and imaginative acrylics of dredging ships. Mr Kerrebijn, who was at work in the IADC booth all week, attracted a great deal of attention with his "surreal painting depicting foreign dredgers at work in New York harbour", as it was described by Peter Hamburger.

Anna Csiti, Executive Director of CEDA, was asked to pick the winning raffle for the IADC painting. Left to right: Mr Albert Savage, WODA Chairman; Dr Joseph Westphal, Assistant Secretary of the Army; Mr Robert Hopman, WEDA President and winner of the prize; Ms Csiti and Mr Hamburger who presented the painting on behalf of the IADC.

WODA Environmental Policy on Dredging

The World Organization of Dredging Associations (WODA) recognises that carefully designed and well-executed dredging conducted in an environmentally sound manner contributes to a stronger economy. WODA believes that dredging projects can be conceived, permitted and implemented in a cost-effective and timely manner while meeting environmental goals and specific regulatory requirements.
WODA is committed to the development and implementation of appropriate environmental safeguards and performance guidelines for construction, maintenance, mining, and remedial dredging. Beneficial use of dredged materials is encouraged. Open lines of communication among stakeholders, such as port interests, dredging contractors, regulatory agencies, other business interests, environmental interest groups, and the public, should be standard elements of any project.
WODA encourages investment in and expeditious transfer of new technologies, and the development of new, more efficient techniques for improving the evaluation and safe handling of dredged material.

(Signed)
Albert J. Savage III, Chairman
WODA Board of Directors

The lucky winner of the prize painting was WEDA's president Robert Hopman, who was clearly delighted.

Award-winning Papers

On the final day of the conference at the closing ceremonies, two best paper awards were presented, one by Dredging Contractors of America for a paper by Marian Rollings, a member of the Research Civil Engineering at USACE-WES, and the other by the IADC. Mr Peter Hamburger presented the IADC Award for the best paper given by an author younger than 35 years old.

The IADC presents this award annually at an important conference in an effort to encourage young people in the field of dredging. The IADC Award winner receives a monetary prize (US$1000), a certificate of recognition as well as publication in *Terra et Aqua*. This year's winner is Mr Akinori Sakamoto, a mechanical engineer at TOA Corporation, Japan, for his paper "Cement and soft mud mixing technique using compressed air-mixture pipeline-efficient solidification at a disposal site".

Mr Akinori Sakamoto receiving the IADC Award for the best paper by a young author from Mr Peter Hamburger, with Mr Albert Savage, WODA Chairman, looking on.

Mr Hamburger's remarks upon presenting the award touched briefly upon the issue of the "restricted markets which even seem to exist in countries with a recognised history of free enterprise and fair competition". "In general", he said, "protective economic measures taken in any country are more a problem for that country than for other countries....We at the IADC would just like to make clear that as representatives of the private dredging industry, we are are more than able to offer...highly advanced dredging technology to assist in solving any existing dredging related problems anywhere in the world".

His remarks were met with quite a range of reactions from a great deal of enthusiasm to a bit less – depending on which country you came from.
The discussion will certainly continue into the 21st century.

Charles W. Hummer, Jr.

DOER: A Major Dredging Research Programme

Abstract

Much like the Public Works Ministries in many other countries, one of the major responsibilities of the US Army Corps of Engineers Civil Works Directorate is supporting the nation's infrastructure. A vital part of this infrastructure is the construction and maintenance of 25,000 miles of navigable waterways. These waterways serve over 400 ports, including 130 of the nation's 150 largest cities.
There is a huge difference in geological, meteorological, environmental, morphological and physical differences from waterway to waterway and port to port.
The diverse range of conditions makes it difficult, if not impossible, to set up programmatic standards or develop solutions that apply equally to all sites and situations. To meet these needs, the United States Government under the auspices of the US Army Corps of Engineers has authorised a new major multi-year dredging research programme called the Dredging Operations and Environmental Research (DOER) Programme.

Charles Hummer served as Environmental Control Officer for the Governor of the former Panama Canal Zone and as Assistant Chief of the Dredging Division, Panama Canal Company.
He was later Chief, Dredging Division for the US Army Corps of Engineers Headquarters in Washington, DC, a position he retired from in 1989.
He continues to act as a dredging and maritime consultant, as well as editor and writer in the field.


Charles W. Hummer, Jr.

Introduction

A major element of any waterway construction and maintenance programme is the extensive dredging requirement. The Corps national dredging programme involves an average of 250 to 300 million cubic metres annually at a cost of US$400 million. Dredging is the single most costly element of the Corps of Engineers budget. The Corps also grants permits to the private sector for dredging and disposing of an additional 100 million cubic metres of sediment annually.

Sediments in many urbanised and industrialised harbours are severely contaminated from years of unregulated discharges and runoff. This situation is made more difficult by the rapidly diminishing capacity of present disposal facilities and by high levels of resistance to constructing new facilities in traditional locations. Non-controversial disposal options are quickly disappearing, and dredging options are increasingly constrained by environmental windows and other restrictions for the protection of sensitive aquatic resources and wildlife.

Today's dredging managers are faced with complex situations in which they must achieve a cost-efficient operation while simultaneously considering the risks associated with various types of dredging equipment, timing of dredging and disposal operations, selection of an appropriate disposal alternative, and other important factors.

Research Tailored to Demonstrated Needs

The DOER programme recognises the necessity of balancing the operational and environmental requirements and is intended to develop tools and techniques to meet this challenge. The programme was developed from the bottom up; that is, a survey of needs of the Corps far-flung field offices served as a basis for identifying what needed to be done and the priorities for the various aspects of the programme. The use of a continuing involvement of field dredging managers in an advisory role has been successful in past research programmes and will be an integral part of the management of this new programme. A major advantage of this approach is to accommodate changes in direction as new needs evolve and other research initiatives prove impractical.

Technology Transfer a Primary Emphasis

Research results only realise a true value when they are publicised to potential users. Therefore aggressive technology transfer to the field operators and managers is a critical element of the programme from the outset. In addition, the Corps of Engineers is including other Federal and state agencies in the planning and implementation of the programme. These partnering agencies include the Environmental Protection Agency (EPA), the US Fish and Wildlife Service and the National Marine Fisheries Service.

Bridge to the Next Century

DOER is the latest in major dredging-related research spearheaded by the Corps of Engineers. It is intended to address a full array of research needs related to dredging and dredged material disposal and the research will span into the new millennium. The first major research programme was the Dredged Materials Research Programme (DMRP) that started in the early 1970s as the sensitivity to environmental issues gave impetus to finding environmentally sound solutions to dredging problems. The next research programme was the Dredging Research Programme (DRP) which was more attuned to research and development of innovative operational solutions to problems. The current programme, DOER, is envisioned as an 8-10 year $48 million programme and it will have amore eclectic set of objectives, ranging from operational, engineering and technical to environmental.

DOER is divided into six specific applied research focus areas each with work tasks describing objectives, research methodologies, user products and time/cost schedules. These focus areas are:
– Nearshore placement of dredged materials
– Environmental windows for dredging operations
– Contaminated sediment characterisation and management
– Instrumentation for dredges and site monitoring
– Innovative dredging technology
– Ecological risk management for dredging disposal projects.

Nearshore and offshore placement of dredged materials
Nearshore and offshore locations present a variety of challenges and opportunities for the cost-effective, environmentally acceptable placement of dredged material. In addition to being costly, conventional disposal practices usually remove the sandy and silty materials required to build and replenish beaches, barrier islands, and other land features. In the case of contaminated dredged material, the demand for offshore capping and confined disposal projects is bound to increase as upland and other traditional options become scarcer.

Placement options for contaminated and non-contaminated materials are now constrained by a lack of predictive tools, assessment capabilities, and operational guidance for the physical aspects of placement/environment interactions. DOER nearshore research focusses on predicting the time-dependent movement of sand/silt mixtures, including material sorting and the fate of finer fractions. Such predictions are essential for estimating long-term benefits from repeated placement of maintenance dredged material and for assessing risks to nearby resources. In addition, guidance will be developed to further enhance beneficial uses, to determine impacts to key species, and to minimise effects on fishery resources. For offshore confined disposal facilities (CDFs) and capped mounds, research will focus on developing siting and configuration criteria, predicting the performance of various construction techniques, evaluating long-term behavior and integrity, and providing integrated design guidance.

Benefits from nearshore work in this area will include:
– improved use of maintenance dredged material for shoreline stabilisation,
– increased acceptance by regulatory agencies of nearshore placement as a viable long-term disposal alternative, and
– lower costs for overall maintenance dredging operations.

For offshore placement of contaminated material, benefits will include improved design capabilities and confidence, and significantly expanded options for safe, cost-effective disposal.

Environmental windows for dredging operations
Environmental windows impose serious constraints on dredging operations. Although widely applied, they are often based on little technical information. There is a lack of consistency for recommended windows, even when protecting the same resource, and they typically result in limited scheduling and equipment options, increased costs, and potential for navigation safety hazards. Specific categories of windows (e.g., to protect salmon runs and nursery habitat in New England) will be identified that pose severe impediments and significantly increase project costs impact moderate to large volumes.

A survey of existing and proposed environmental windows will quantify the relationships between each category of window and impacts. Only those high profile windows that maximise return of research funds into the dredging programme will be selected for further study.

DOER is synthesising the state-of-knowledge of individual issues, evaluate their technical basis, and produce guidance for resolvable issues, given existing information. Issues needing further research are being prioritised based on probability of resolution with reasonable investment of funds and potential benefit. The effectiveness of equipment and/or operational measures in reducing the need for environmental windows will be documented.

DOER is developing partnerships with the Corps field offices and environmental resource agencies to evaluate current environmental windows and implement research necessary to resolve seasonal restrictions. Where windows are technically justified, guidelines for implementation that optimise resource protection while retaining flexibility for project contracting and scheduling are being developed. Benefits will include:
– technical basis for appropriate application of environmental windows,
– improved inter-agency coordination by removing speculative arguments,
– increased efficiency in contracting and equipment, scheduling, and
– reduced project dredging costs.

Contaminated sediment characterisation and management

The presence of chlorinated hydrocarbons (dioxins) and other man-made contaminants in sediments is a potential threat to the environment and human health that results in significant project delays and management cost increases. Contaminated sediments unsuitable for conventional disposal may be confined, contained, or not dredged.

CDFs are located on land or in areas of relatively sheltered water. Many CDFs are approaching capacity for which replacement is required. Future CDF locations will include non-traditional areas such as offshore sites. Capping contaminated sediment with clean dredged material is a related option for open water disposal. It has significant potential to increase disposal capacity, but application to deeper waters or high-energy environments requires additional environmental investigation.

DOER will develop risk-based effects assessments for contaminated dredged material that include contaminant control, treatment, and removal technology and reuse of marginally contaminated sediments from existing CDFs. The risk process for contaminated sediments includes hazard assessment, contaminant pathway testing, exposure assessment and identification of contaminant controls and treatment (Figure 1).

Research will develop low-cost, rapid, and interpretable

Figure 1. As part of contamination sediment characterisation and management, a researcher is using a pipette to add cells to wells in microtitreplate for the H4IIE dioxin screening assay.

biological screening methods. These will also reduce the number of chemical analyses and quickly identify contaminated sediments and marginally contaminated dredged material in existing CDFs that can be reused.

CDF research will develop and validate contaminant controls, treatment methods, and management techniques. Design of CDFs as treatment structures, groundwater and surface water control, and overall contaminant retention will be emphasised. Design criteria for treatment and/or control of high-profile contaminants in CDFs will be developed. Tools for predicting capped material chemical migration will be refined. Environmental aspects of capping and CDFs will be developed jointly with physical aspects under the Nearshore and Offshore Placement focus area. Benefits will include the ability to:
– improve the cost-effectiveness of identification and assessment procedures,
– reuse existing disposal capacity for contaminated materials, and
– design and manage disposal facilities for enhanced capacity, treatment, and containment objectives.

Instrumentation for dredges and site monitoring

Improvements in instruments to make measurements are needed to meet increasingly stringent environmental monitoring requirements and to expand automated operational monitoring and characterisation capabilities. The DOER Programme will help bridge the gap between present instrumentation needs and the tendency of commercial firms to direct their product development resources toward broader, non-dredging market segments.

Figure 2. Experimental teeth on a California-style draghead is an example of innovative dredging technology which has improved productivity.

Research will augment domestic and internationally available commercial products where feasible and will support specialised product applications. By developing system standards and specifications and demonstrating prototypes, the DOER Programme will facilitate achieving an overall objective of product implementation and support through the commercial sector. Research in the instrumentation focus area is directed toward developing systems and standards to achieve these goals:

– pay hopper-dredge contracts on a dry-weight basis,
– precisely locate dredging transport and disposal, and
– verify compliance with environmental requirements.

In each case, instrument and system development will be preceded by a thorough requirement analysis to ensure that quantified performance goals are set based on verifiable needs. Where competing technologies are involved, independent screening procedures based on these performance goals and on existing technology, theory, and data will be used to assess which candidates, if any, warrant further development. Benefits from work in this area will include:

– tools for compliance with environmental requirements,
– positive incentives for increased dredging efficiency, and
– reduced potential for sustainable contractor claims.

Innovative dredging technology

During a multi-year research programme, technological opportunities may be encountered that are outside the initial scope of work. This focus area will serve as a coordination and evaluation center for such opportunities. These future advances may emerge from other DOER focus areas, related R&D activities, or private industry both in the US and abroad. The capability to recognise these opportunities, evaluate their potential, and facilitate their demonstration and implementation will provide timely additional options for removing and disposing of dredged material. Examples of candidate technologies include equipment and procedures for capping and systems for dredging contaminated materials (Figures 2 and 3).

A clearinghouse for innovative dredging and disposal technologies is being established. Recent advances in equipment, operational methodologies, and environmental compliance will be catalogued. These advances will be matched to Corps needs articulated by field representatives and Corps headquarters. A screening and evaluation process will identify items with the greatest potential for implementation, high return and increased efficiency.

The next step will be to develop funded demonstration opportunities for high-potential candidates. Some demonstrations may be of sufficient scope and potential to warrant an autonomous proposal. Regardless of the source, all demonstrations will be accompanied by a detailed plan to implement successful technologies into Corps in-house, contractor and permitting practices.

This focus area will promote the evaluation and implementation of innovative dredging and disposal technol-

ogies. Promising technologies will be matched to needs, and the process from identification to operational integration will be fully planned and coordinated.
This rapid process will provide more immediate benefits in the form of improved operations, reduced costs, and environmentally acceptable dredging operations.

Ecological risk management for dredging disposal projects
Fiscal constraints are making the already difficult task of managing the field managers' maintenance dredging/ disposal programme even more difficult. Risk management can promote the more effective use of limited funds through evaluation of critical factors (such as cost, equipment, windows, contaminants, disposal options, shoaling and channel navigability) as well as the consequences of not dredging. A repeatable and defensible framework to quantify this process is missing. Lack of an internally developed framework increases the probability of having one imposed by external sources (e.g., EPA) that does not fit dredging needs.

Risk-based analyses will be required for a wide variety of activities and functions integral to managing dredging and disposal projects. These include:
– facilitate long-term management continuity,
– support decisions or requests,
– choose among closely ranked alternatives, and
– negotiate environmental, engineering and economic issues

A framework for risk-analysis techniques and engineering reliability methods for dredging and disposal processes are being developed. Researchers will identify and rank critical factors and define data collection requirements to evaluate them (e.g., the probability of a given reduced channel depth). Many aspects of the dredging and disposal process have considerable uncertainty; the risk framework will allow a consistent approach to dealing with these uncertainties. Existing risk-analysis techniques are being examined for their potential application to maintenance dredging.

A risk framework integrating dredging and disposal management will be developed. The framework will demonstrate the usefulness of risk-analysis to a dredging manager making difficult decisions on controversial, closely ranked alternatives.

Integration of the International Experience

One objective of the DOER Programme is to capture the successes and promising on-going research existing in the international sector. A conscientious effort will be made to interface the Corps researchers with their counterparts on the international scene. This could mean research projects will be awarded to universities or

Figure 3. Another example of innovative technology for a project-specific environmental problem is the turtle deflection device developed by the US Army Corps of Engineers. Mounted on a TSHD draghead, it is used to avoid the entrapment of sea turtles (an endangered species) through the suction pipe of a TSHD during maintenance dredging in Florida (USA).

other research agencies in Europe or elsewhere around the world and/or partnerships could be established with other Corps researchers.

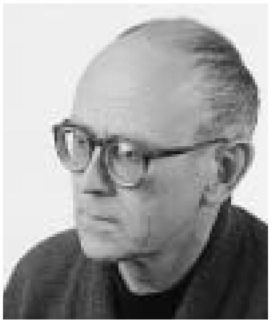
Contacts through the Corps expanding Internet presence can greatly assist in reaching out to utilise these international capabilities (the Corps Dredging Operations Technology Support Home Page at http//:www.wes.army.mil/el/dots/). Information on the Corps dredging programme in particular (including the major contracts advertised and awarded), is available as well as information on ports, navigation projects, waterway commerce and navigation statistics.

Conclusion

The DOER programme demonstrates a commitment to meaningful research in the essentials of dredging technology ranging from operational, engineering and technical to environmental. The objectives and results of this research should provide innovative, cost-effective solutions for dredging operations and environmentally responsible disposal techniques.
These may ultimately be utilised to great advantage by any nation where navigation, waterway transportation and dredging issues constitute an important part of their national interests. Likewise, recognising the on-going research and activities in other parts of the world, there may be some opportunities for substantial international participation in this major research effort.

Udo Hahlbrock and Ingo Freese

Hopper Load Measurement; Some Recent Experiences with a Remote-Operated Data Acquisition and Analysing System



Udo Hahlbrock

Udo Hahlbrock, diplom. Engineer, studied mechanical engineering and marine technology at Technical University Hannover, Germany. From 1973-1983 he was responsible for the development of dredging and deep-sea mining systems at O&K Orenstein & Koppel AG, Lübeck, Germany. For a period of two years he was then sales manager at Menck GmbH, Hamburg, for offshore pile driving and foundation engineering. In 1985 he founded Hahlbrock Marine Technology (HMT).

Ingo Freese

Ingo Freese studied history, philosophy and sociology. He has a Master of Arts and is working on his doctoral thesis. He is responsible for PC applications and data transfer technology at HMT.

Abstract

Hopper load measurement is still a lively field of research and development and several systems have been developed. This paper presents a remote-operated data acquisition and analysing system designed by HMT for the calculation of hopper loads discharged by pipeline. It has successfully been used in a number of land reclamation and beach nourishment projects. The resulting experiences cover both aspects of this work; the data logging and transfer process as well as the analyses of hopper operation.

Operational data, acquired with the ship's measurement system, can be picked up from a serial interface and transferred to a remote location, e.g. the client's office, using GSM mobile phones. Intranet technology proved to be a reliable and easy way to handle network structure for this task. Considerable savings in labour and a very detailed presentation of the hopper operation are typical results of this system.

A measurement concept for the analyses of the hopper discharge process has been developed which uses redundant, independent measurement systems for the calculation of the discharged load. The systems use density and velocity measurement and the TDS (Tonne Dry Stuff) system. A graphical comparison of both results provides a quickly accessible and highly reliable statement about the validity of the measurement. If the soil volume is the basis for payment, the decrease of hopper weight is plotted together with the ship's displacement. Results from this electronic measurement differ less than 1% compared to manual sounding.

However, because of the specific disadvantages of volume measurement, it is recommended that the

discharged solids mass be used as the basis for payment. In this case, the density and velocity measurement is compared with the results of the TDS system to reach redundancy. Being more independent from the soil properties, this method is applicable to all conceivable discharge processes.

This paper was presented at the CEDA Dredging Days in Amsterdam, The Netherlands, and is reprinted here in a revised, illustrated version with permission.
The authors wish to thank the German authorities Strom und Hafenbau, Hamburg and Amt für Land und Wasserwirtschaft, Husum for their continuous support of the work described here.

Introduction

Hopper load measurement is still a lively field of research and development. This is owing to the great variety of influencing parameters emerging with the various processes of loading and unloading, the type and design of the vessel, and the nature of the soil to be dredged. Scrutinising existing hopper load measurement systems clearly shows that there is no single solution to the problem; instead a careful analyses for each individual hopper operation is necessary.

In this context, HMT has developed a data-logging and analysing system for hopper dredgers, which can be regarded as a purpose designed method, taking advantage of some recent developments in computer technology and telecommunication including the fact that:
– handling large amounts of data is no longer a problem even for a standard PC
– network telephone and Intranet technology offer new ways of data transfer
– advanced data processing software eases the analysis process

Designed for the calculation of hopper discharge by pipeline, the system's general approach is to use multiple, independent measurements for the evaluation of a single parameter. In this way, the discharged soil quantity is developed from density and velocity measurement in the pipeline and simultaneously checked with the additional measurement of the ship's draft or the TDS results. A graphical comparison of all results in a single diagram provides a quickly accessible and highly reliable statement about the validity of the measurement. Initial calibration can be performed with manual sounding of the load.

The system gets the data from the ship's measurement and control installation and is operated from a remote location, e.g. the office, to where the data are transferred with intranet technology. In addition to soil discharge, the system makes possible the recording and analysing of all associated process data, such as

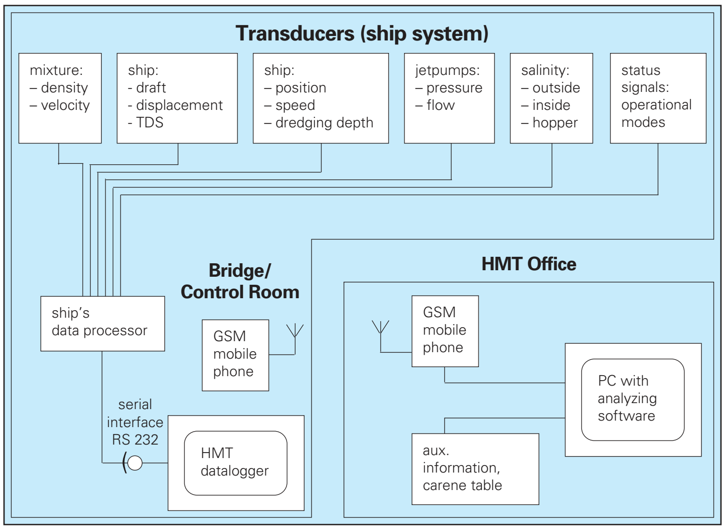


Figure 1. Basic sketch of hopper operation monitoring with remote data aquisition system.

the dredged profile and the effect of desalination of sand loads.

The system has been tested and successfully used in a number of projects including beach nourishment at the island of Sylt and land reclamation for the port of Hamburg. The dredgers involved include some very new designs such as *Cristoforo Colombo, Pearl River, Amsterdam, Gerardus Mercator,* and *W.D. Fairway.*

General Arrangement of the System

Tracing and documentation of hopper dredge performance generally needs an extensive measurement system to cover all operational modes. As the client is obviously not in a position to install equipment of that size, the only solution is to make use of the ship's measurement and control system. With this approach, it becomes the contractor's duty to operate and carefully maintain the various transducers and deliver the measurement results as raw data for further handling by the client.

Modern hopper dredgers use a great number of sensors for the control and monitoring of the dredging process. The sensors send their signals to the ship's main processor, where they are used for the various control functions.

From this existing measurement system, the parameters necessary for the analyses are chosen according to the special needs of the client. Figure 1 shows a list of basic parameters, which have been used during this year's projects. Using a software module, which is a part of the ship's software package, the signals are grouped and transformed according to a pre-defined data protocol and then delivered to a serial interface (RS232).

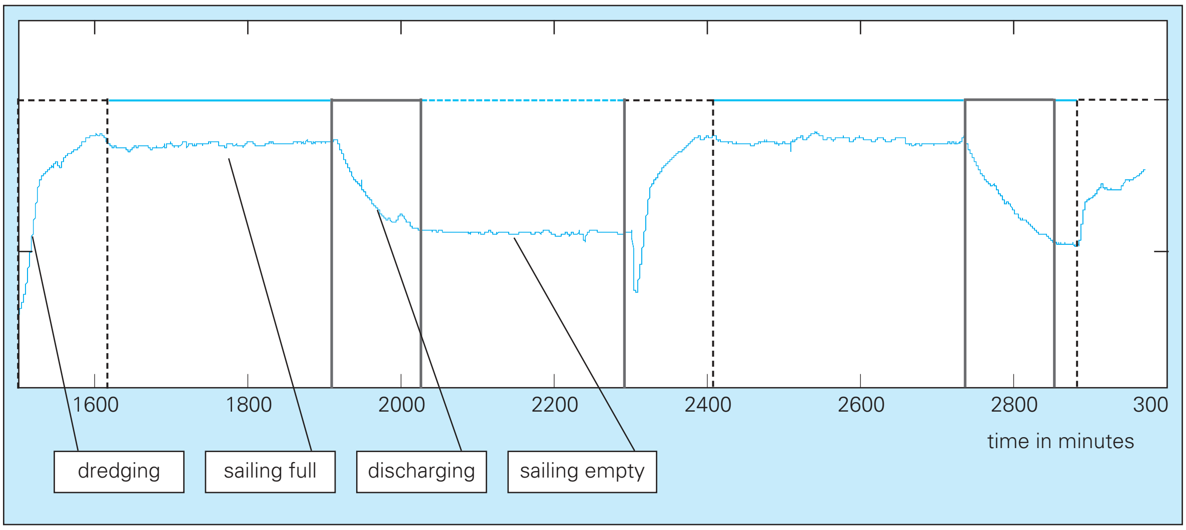


Figure 2. Displacement and status signals versus operational time.

The client uses a standard PC which is assembled on board the hopper dredge. Using data-logger software, the data are picked up from the serial interface and written to the hard disk of the PC. This procedure runs continuously from the beginning to the end of the project, thus creating a continuously growing data matrix. Data format is plain ASCII. Experience shows that the measurement interval (time between two consecutive sets of data) should be in a range of 15 to 20 seconds. An individual set of data comprises a number of approx. 40 to 50 parameters.

The receiving PC is running in multi-tasking mode, making simultaneous operation of data logging and data transfer possible. The data transfer is done with a GSM mobile phone, using Intranet technology as basis network structure. Projects done this year clearly showed that the D2-Net is suitable for the offshore areas of Sylt and Cuxhaven. If the transfer has to be done from areas, where no GSM net is accessible, a satellite phone should be used.

With this system it is possible, to collect data from the ship's data logger at any time. When a section of the data matrix is transferred to the office, data evaluation starts with an overview of the operation, which the hopper has performed since the last checking interval. Figure 2 shows an example of this overview.

The example displays a one-day section of the data matrix including two complete trips. Normally, the operational modes of the hopper dredger are determined by the status signals alone. However, as experience shows that these signals tend to fail frequently, they are plotted together with the displacement. Using this method the individual dredging modes can be distinguished very accurately.

Owing to the great operational differences, each individual dredging mode must be analysed separately. The discharged soil quantities and the desalination process were the focus of interest during recent projects, therefore the analysing work was confined to the discharging and the sailing full mode. Analysing the dredging mode is also possible, but this work has not yet been carried out.

Analysing the Discharge Operation

Electronic measurement of hopper load volume

The new method, which introduces electronic measurement, is in competition with the traditional system of manual sounding of the hopper load volume. As in the past there was no other way possible, soil volume is still the contractual basis for the discharge, although obviously the volume may change according to the treatment of the sand mass.

Calculating the soil volume from a measured array of mixture-density and -flow data is fairly easy, if the necessary soil parameters are known:

$$Vb = \sum_{i} \left[\left(\frac{\Pi}{4} \cdot dr2 \cdot vm_i \right) \cdot \left(\frac{\rho gt_i - \rho w}{\rho b - \rho w} \right) \cdot \delta ts_i \right] \quad (1)$$

where,

Vb	m^3	soil volume of hopper load
i	-	number of data sets
dr	m	pipe diameter
vm	m/s	mean mixture velocity at measuring interval
ρgt	t/m3	mean mixture density at measuring interval
ρw	t/m3	density of water
ρb	t/m3	density of soil (saturated)
δts	sec	time interval

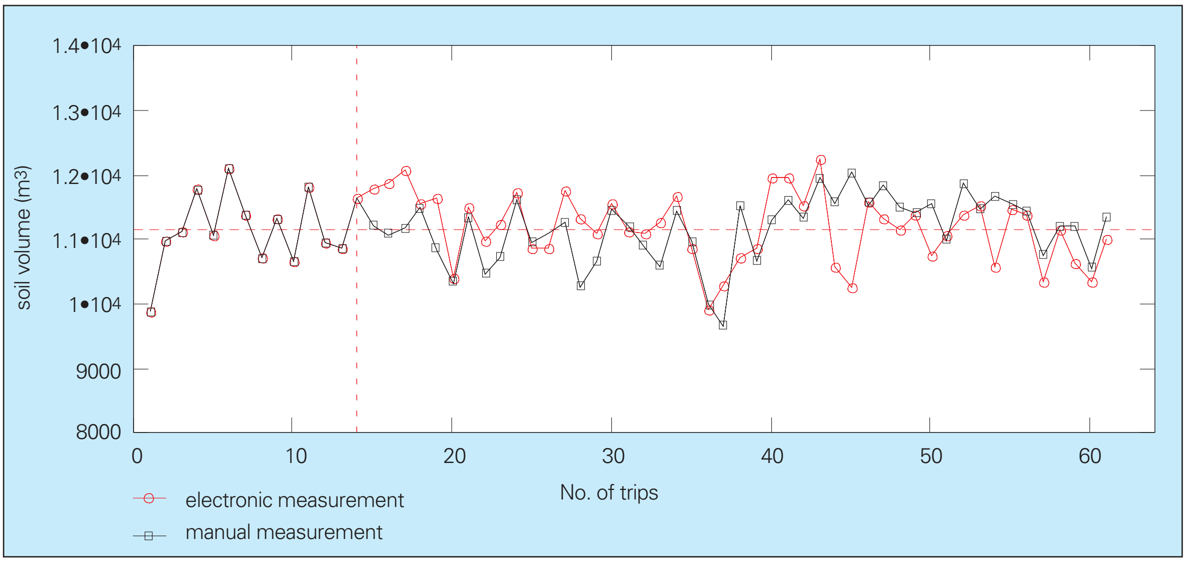


Figure 3. Volume measurement, hopper dredger Amsterdam.

The parameter in question is the saturated soil density (in the hopper), which is dependent on soil properties and therefore dependent on the dredging location. As different hopper dredgers working at the same location have shown different values of soil density, the type of hopper also has an influence on this parameter.

To overcome this problem, a calibration method has been chosen so that the value of the soil density is developed from a number of manual soundings at the beginning of a project. During the calibration phase, which may include approx. 10 to 15 trips, the manually measured volume is introduced into the rearranged Equation 1, to calculate the soil density. The mean of these calculated density-values is then chosen for the calculation of the volume for the rest of the project.

The main advantage of this method is that there is no need for a totally correct calibration of the density and velocity transducers, as any constant error is compensated by the calculated factor. The main disadvantage of this method is its dependency on the location. At every new location the calibration process has to be repeated. This method has been used for all the projects listed later in this paper. From the great number of results an example is shown in Figure 3. See also Figure 4.

During the first 14 trips, the value for the soil density has been calculated to be 1.8871 t/m^3. The respective standard deviation is 2.142 %. After the calibration procedure, the volume has been measured both manually and electronically. The result shows, that although there are differences during the individual trips, the mean values are nearly identical (Table I).

Taking normal accuracy levels of dredging into consideration, this result can be regarded as very accurate. After experiencing similar results with other projects,

Figure 4. The Amsterdam working on harbour filling in Hamburg.

Table I. Volume measurements

	Manual	Electronic
Total volume	680,432 m^3	681,555 m^3
Mean volume per trip	11,155 m^3	11,173 m^3
Difference	0.165 %	0.165 %

the conclusion can be drawn that this type of electronic measurement can be recommended as a reliable tool. The fact that there are enormous savings if the work can be done from any remote site should also be mentioned.

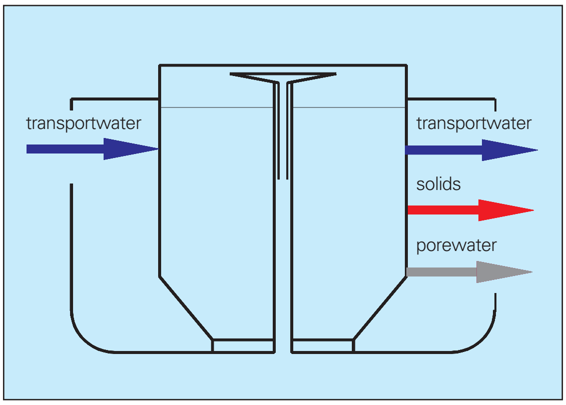


Figure 5. Mass balance during hopper discharge.

Checking the results with additional measurement
It may be regarded a disadvantage of the electronic measurement that the parameter which is the key issue for the economic success of the project is developed from a single measurement system only. As all systems are susceptible to failure, an additional measurement system with which the results of the density and velocity transducers can be checked is needed.
The method chosen is based on the idea that the discharge of soil must be proportional to the decrease of the ship's displacement.

As a first approach it can be assumed that the water fed to the hopper to prepare the soil for hydraulic transport is of the same magnitude as the discharged transport water. In this case the loss of weight is only owing to the discharged solids and the pore water (Figure 5). Although practical experience shows that this assumption is not continuously valid, it opens a possibility for a first order check of the volume calculation. For this reason the accumulated loss of weight is calculated according to Equation 2 and plotted together with the displacement curve in a single diagram. (Figure 6). See also Figure 7.

$$M1_i = dpl_0 - \left(\sum_{i=0}^{i} \delta Vb_i \right) \cdot \rho b \qquad (2)$$

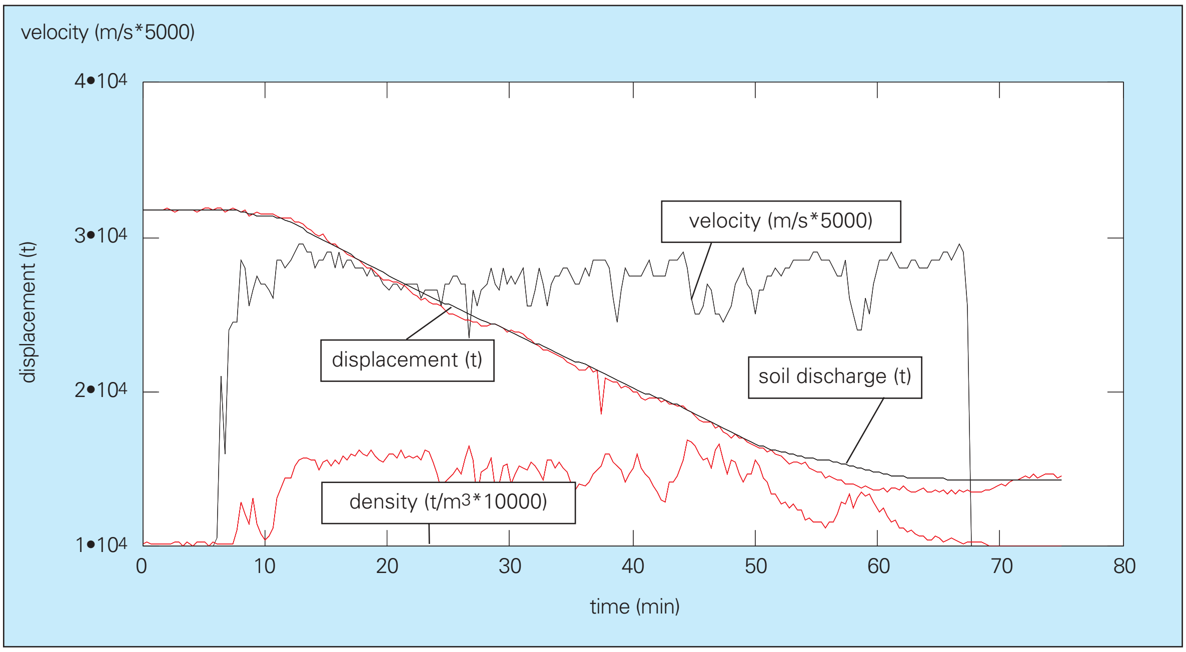
where,

Ml	t	accumulated loss of weight owing to soil discharge
dpl_0	t	displacement at start of discharge
δVb	m3	soil volume at measurement interval
ρb	t/m3	density of soil

The example shows a nearly perfect coincidence between the displacement and the soil discharge. As both parameters are measured with completely different systems, the correctness of the results is most probable. If density or velocity measurement fail, or if the soil density value is not correct, these incidents can directly be seen from the diagram. In that case, there is a deviation of the curves at the time of the incident.

The process of supervising the discharged lodes from the office location comprises picking up the data from the ship and evaluating the volume with discharge diagrams. Carried out once or twice a day, this procedure takes only very little time, but offers a very comprehensive analyses of the hopper operation.

Figure 6. Example: Discharge diagram hopper dredger Pearl River.



Other parameters such as desalination, ship's speed and heading, dredging depth and such, and a complete breakdown of operational time periods can, of course. also be documented. These items are, however, not the subject of this paper.

Improved Methods

As mentioned above, measurement of the soil volume is the crucial point of all electronic measurement systems. Unfortunately, the soil density varies with different soil types at different locations and the assumptions of Figure 5 cannot always be met. Consequently, the described method is confined to those projects where the necessary calibration work is only a small portion of the total work. In addition, the checking function of the displacement curve cannot be used for all types of hopper design.

All these problems can be overcome if, instead of the soil volume, the solids volume or mass are taken as basis for the load calculation. While the soil density varies greatly, the solids density is confined to very close limits. This is also the basic idea of the TDS system, which uses the draft and the load level as basic parameters for load calculation. See under "References" Rijkswaterstaat for a detailed description of the TDS system.

However, if the TDS system is the only tool for load measurement, this again does not meet the demand for redundancy. Problems may emerge, if one of the many elements of the system do not work properly.

Figure 7. The Pearl River working on land reclamation, Hamburg.

It is also known, that the TDS system has difficulties coping with swell, e.g. if the discharge is done via an offshore SBM. It is for that reason, that the combination of the TDS system with the density and velocity measurement seems to be the best solution.

To compare the results of both systems, a comparable parameter has to be chosen. Preferably this should be the discharged solids mass, which is the key parameter of the TDS system. The corresponding value of the density and velocity measurement is calculated with the introduction of the solids density into Equation 1:

$$Vf = \sum_{i} \left[\left(\frac{\Pi}{4} \cdot dr^2 \cdot vm_i \right) \cdot \left(\frac{\rho gt; - \rho w}{\rho f - \rho w} \right) \cdot \delta ts_i \right] \quad (1a)$$

Figure 8. Example: Discharge diagram hopper dredger Amsterdam.

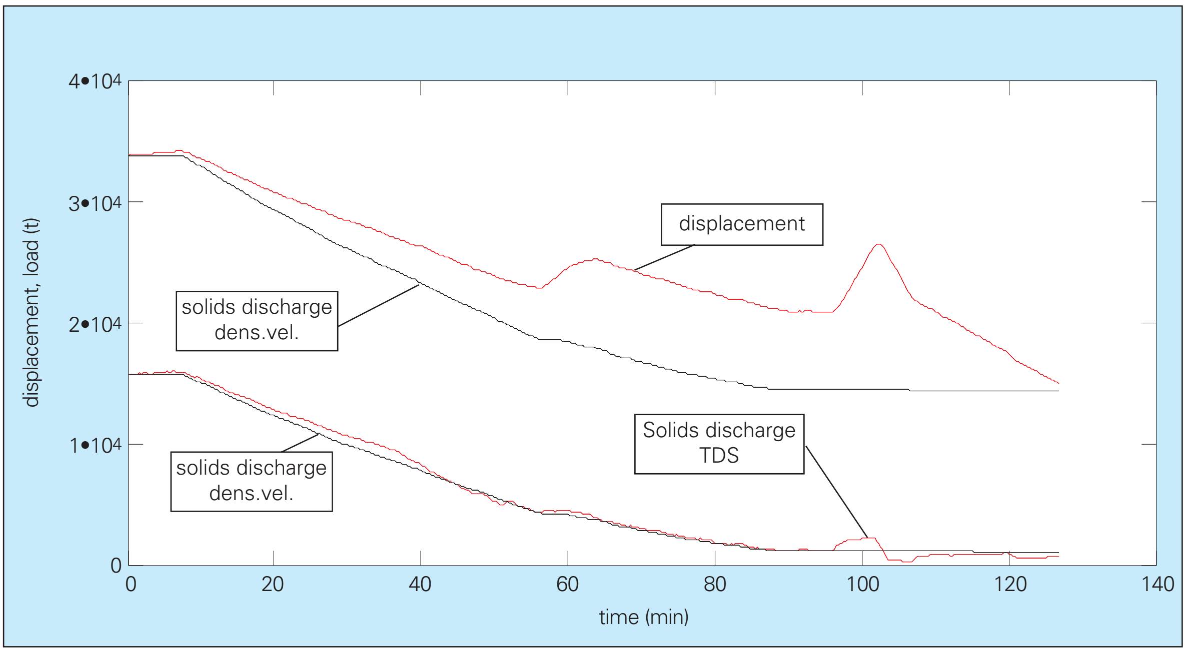


Figure 9. Geopotes 14, harbour filling at Hamburg.

Figure 10. Gerardus Mercator, harbour filling at Hamburg.

where,

Vf	m^3	solids volume of hopper load
ρf	t/m^3	solids density

The corresponding solids (mass) discharge is:

$$M1f_i = tdsto_0 - \left(\sum_{i=0}^{i} \delta Vf_i \right) \cdot \rho f \qquad (2a)$$

where,

Mlf_i	t	accumulated loss of weight due to solids discharge
$tdsto_0$	t	solids mass at start of discharge

With this calculation both values for solids mass discharge can be plotted in a single diagram (bottom lines of Figure 8).

The example shows, that there is a perfect coincidence of both curves, although they are measured with completely different systems. As already stated above, this coincidence of results of two independent systems is a guarantee for a correct measurement. From another viewpoint, this presentation of results can be regarded as a method for double-checking both measurement systems. In this way the oscillation of the TDS curve at the end of the discharge process can clearly be detected as a temporary failure.

During this year's activities it was experienced, that the solids presentation was always applicable with good results, even in those situations where the soil presentation as described under "Checking the results with additional measurement" did not offer a realistic solution.
This too can be demonstrated with the example of Figure 8, where the upper two lines show the soil method. It is obvious, that the results of the density and velocity measurement cannot be checked with the displacement curve, as the unloading process of this ship does not follow the assumptions expressed in Figure 5. Instead this hopper uses an increasing water level during the discharge process.

Summary of Projects Using the HMT Data Acquisition and Analysing System

The methods described in this paper have been developed since 1993, with test projects in 1993 and 1996 and full operational application at a number of projects in 1997. As every project has its own specific history, this paper can only present some significant experiences (Figures 9, 10, 11 and 12). The individual projects are listed in Table II.

During all projects, measurement of soil volume during the discharge process was the most important issue. For this reason, the electronic measurement described earlier was used, incorporating individual calibration procedures at every location and for every hopper dredger.

The results show that a high overall precision (less than 1% difference compared with manual sounding) can be reached if the calibration procedure is carried out carefully. It also became clear that under certain environmental conditions, such as discharging in swell, the density velocity measurement is the only method possible.

Figure 11. Volvox Scaldia, beach nourishment at Sylt.

Recommendations

Although the system has proven to be practical, the disadvantages, i.e., the dependency on different soil properties at the individual locations, became visible. With one project there were so many different locations, that the necessary calibration work nearly

Table II. Test projects using the HMT data acquisition and analysing system.

Year	Project	Hopper Dredger	Status / Results
1996	Beach nourishment, Sylt	Christoforo Colombo	successful test
1996	Harbour filling, Hamburg	W. D. Gateway	successful test
1997	Maintenance dredging, Hamburg	Ijssel Delta	measurement of dredging performance
1997	Harbour filling, Hamburg	Amsterdam	measurement of dredging performance and desalination
1997	Harbour filling, Hamburg	Geopotes 14	measurement of dredging performance and desalination; volume measurement impossible because of too many dredging locations
1997	Land reclamation, Hamburg	Pearl River	measurement of dredging performance and desalination; volume measurement impossible because of problems with velocity sensor
1997	Harbour filling Hamburg	Gerardus Mercator	measurement of dredging performance and desalination; volume measurement impossible because of problems with density sensor
1997	Beach nourishment, Sylt	Coronaut	measurement of dredged volume is the basis for payment
1997	Beach nourishment, Sylt	Volvox Scaldia	measurement of dredged volume is the basis for payment
1997	Land reclamation, Hamburg	W.D. Fairway	desalination measurement

Figure 12. W.D. Fairway working on land reclamation, Hamburg.

covered the total duration of the project, thus jeopardising the success of the electronic measurement.

To overcome these disadvantages, it is highly recommended that the solids mass calculation be used as a basis for payment for future projects. The recommended method should combine density and velocity as well as TDS measurement and present the results in single diagrams as described under "Improved methods". This procedure guarantees high precision and reliability.

A further major experience was the dependency of the electronic measurement on the reliable function of the measurement equipment, mainly the density and velocity transducers. Although self evident, this simple demand could not be met at a number of projects, thus preventing the application of the system. Future contracts definitely have to put more emphasis on this issue.

The method of remote data acquisition and transfer proved to be very successful. All elements including hardware and software showed excellent operational performance with only very little downtime. The D2 network can be regarded a useful tool, although it must be accepted that there are certain time periods where data transfer is difficult.

The fact that all hopper operations can be electronically monitored from the client's office, offers a number of benefits for the client. Compared to manual survey, there is of course a great reduction of necessary manpower. Moreover, in case of any discussions with the contractor, the detailed recording of all operational procedures, which comes as a by-product of this method, can be regarded as an indisputable basis.

Conclusions

A remote–operated data acquisition and analysing system designed by HMT for the calculation of hopper loads discharged by pipeline has successfully been used in a number of land reclamation and beach nourishment projects, covering both data logging and transfer process as well as the analyses of hopper operation.

Operational data, acquired with the ship's measurement system, can be picked up from a serial interface and transferred to a remote location, e.g. the client's office, using GSM mobile phones. Intranet technology proved to be a reliable and easy to handle software for this task. Considerable savings in labour and a very detailed presentation of the hopper operation are typical results of this system.

A measurement concept for the analyses of the hopper discharge process has been developed which uses redundant, independent measurement systems for the calculation of the discharged load. The systems use density and velocity measurement and TDS. A graphical comparison of both results provides a quick accessible and highly reliable statement about the validity of the measurement. If the soil volume is the basis for payment, the decrease of hopper weight is plotted together with the ship's displacement. Results from this electronic measurement differ less than 1% compared to manual sounding.

However, owing to the specific disadvantages of volume measurement, it is recommended to use the discharged solids mass as basis for payment. In this case the density and velocity measurement is compared with the results of the TDS system to reach redundancy. Being more independent from the soil properties, this method is applicable to all conceivable discharge processes.

References

Rijkswaterstaat, Netherlands Ministery of Transportation and Water Management.
Technische Documentatie voor het Tonnen Droge Stof Systeem.

Hahlbrock, U.
"Betriebssteuerung und Analyse mit DFÜ", *HANSA,* 132. Jahrg. Nr. 10, 1995.

Charles W. Hummer, Jr.

Book/ Periodicals Reviewed

Dynamics of Marine Sands, A Manual of Practical Applications.
Thomas Telford Publishers.
249 pp, hard cover, illustrations. UK£ 50.

Richard Soulsby

The author describes the scope of this book, "as being restricted to non-cohesive sediments and mainly to the marine context, although some of the material can also be applied to estuaries and rivers. Its main focus is on those aspects of sediment dynamics that are of concern primarily to civil engineers, oceanographers, earth scientists and environmental scientists."

He also correctly points out that the book and the subject are of great practical importance for engineering applications, but it is also a fascinating and challenging area of academic research. This book attempts to meld those somewhat polarised audiences or objectives and does so by summarising research results in a unified form, presenting worked examples and case studies and by highlighting those areas where understanding is deficient and error bounds are large.

The book is organised into 13 chapters. In addition, it has 31 examples, 11 tables and 33 figures. The references presented are extensive and the book has a good index. The reader will find the organisation of the book useful in evaluating its value. The chapter headings give an indication of the subject matter: Properties of water and sand; Currents; Waves; Combined waves and currents; Threshold of motion; Bed features; Suspended sediment; Bedload transport; Total load transport; Morphodynamics and scour; Handling the wave-current climate; and Case studies. References and Index complete the book.

This is a companion volume to the *Estuarine Muds Manual* and the *Manual of Sediment Transport in Rivers* and replaces the earlier *Manual of Marine Sands*, all of which are technical reports issued by Hydraulics Research Wallingford in the UK. The book summarises the main processes determining the behaviour of sand in marine environments. The goal is to provide methods for calculating the various hydrodynamic and sediment dynamic quantities required for marine sediment transport applications in an accessible and unified form. The book is intended to be a reference and "how-to-do-it" manual, thereby keeping lengthy derivations and discussions to a minimum.

A special software package, SandCalc, was developed to complement the book. It is a Windows-based system for use on a personal computer. Many of the examples presented in the book are easily calculated using SandCalc. There was no clear indication as how the reader can obtain the software package, but presumably it can be obtained from the publisher, the author or HR Wallingford.

Each of the chapters and subchapters or sections is generally divided into two sections. The first is entitled "Knowledge" and presents the theory of the particular subject. This often involves some fairly mathematical presentations after an introductory narrative. The second section is entitled "Procedure" and is generally directed at the practising engineer or application of the particular theory being presented. It is an effective progression of presentation on this sometimes fairly esoteric subject matter. Taken as a whole, the Knowledge and Procedure sections complement each other.

As a reference or text on a very technical subject, the book is surprisingly compact which becomes clearly noticeable when reading through and finding that it is comprehensive in covering the subject matter and doing so with economy of presentation. In this regard, the author's background as a practising engineer and a researcher has served him and the reader well.
He seems to have realised his goal of bridging the theoretical and the practical in a single modest-sized volume.

For the dredger or engineer involved in dredging related technical matters, the knowledge of the dynamics of marine sediments seems crucial. Accordingly, the volume is a recommended addition to the technical library of the individual engineer or researcher as well as their organisations technical libraries.

The publication may be obtained from:
Thomas Telford Publications
1 Heron Quay, London, E14 4JD UK
URL: http://www.t-telford.co.uk

American Society of Civil Engineers
Publications Sales Department
345 East 47th Street
New York, NY 10017-2398 USA

Mauruzen Co. Ltd., Book Department
3-10 Nihonbashi 2-chome
Chuo-ku, Tokyo 103 Japan

Wear of Rock Cutting Tools, Implications for the Site Investigation of Rock Dredging Projects.
A. Balkema. Rotterdam, The Netherlands/ Brookfield, Vermont. 1997. Hardcover, 327 pp, llustrated.
NLG 185 / US$95.00 / £62.

P. N. W. Verhoef

As the author states in his preface, this book is the result of a study that took place in response to the need felt by dredging contractors to clarify problems related to the prediction of cutting tool consumption rates during rock dredging. The project that resulted in this book was sponsored from 1989-1997 by the Dutch Technology Foundation, STW. A companion volume, *Wear of Rock Cutting Tools: Laboratory Experiments on the Abrasivity of Rock*, was published in 1995.

The subject of rock dredging is a relatively new development. For many years if competent rock was to be dredged it was first drilled, then blasted. The resulting fractured rock was then dredged using dipper dredgers, grab dredgers or backhoes. In the 1960s, cutter suction dredges were used in the United States to dredge rock using strengthened dredgers and cutterheads with hardened and often replaceable cutters. This methodology has been refined over the years as materials and cutter designs were studied and improved. Nonetheless, the use of cutterhead dredgers for rock dredging has resulted in unwelcome surprises for the contractors: For instance, when excessive wear occurs which results in costly replacement of equipment elements, delays in project completion and large cost overruns.

These experiences led to the concerted study of cutter tools and wear prediction. It also led to the acceptance that site condition reports when rock dredging is involved must have good reliability if wear prediction is to have any credibility. These circumstances resulted in the research project that is being reported in this book.

The book is organised in four parts; namely:
- Problems of wear in rock dredging;
- Rock properties influencing cutting and wear;
- Application to practice; and
- Site investigation for rock dredging contracts.

Each of the parts is complete in its subject matter and contains its own conclusions. For instance, in "Part A: Problems of wear in rock dredging", the author outlines the problems, discusses the relationship to cutter suction dredgers, outlines the concepts of wear processes, the influences on site geology to wear and, finally the geotechnical interpretation of the site investigation reports. In this part, the author presents a case study and appraisal of one of the major projects where excessive wear resulted in extraordinary cost overruns.

"Part B: Rock properties influencing cutting a wear" discusses the influence of rock structure and discontinuities in rock mass. It proceeds to present information on the cutting of rock, models for predicting rock cutting, the hardness of rocks and minerals, tests to determine abrasiveness, wear mode theory and the conclusions that can be drawn from these subjects.
"Application to practice" comprises Part C. This part looks at the experience of specific projects; the observations one can use in rock trenching and the effects of rock properties on performance. Finally, this part assesses methods for excavation performance, for tunnel boring machines, rock ripping, rock dredging, rock excavation and the use of a fuzzy expert system for assessments.
Part D involves the "Site investigation aspects of rock dredging contracts". The various elements of site investigation, such as, boring and sampling, data requirements and the geological and geomorphologic investigation components are discussed. Part D concludes with wear assessments within site investigations for rock dredging, including rock factors involved in excavation and tool consumption and monitoring of excavation and tool consumption during dredging.

In addition, the book has five appendices:
- Rock identification and classification procedures for engineering purposes;
- Definitions for rock mass description;
- Intact rock strength;
- The brittle-ductile transition; and
- Petrographic description.

The publication may be obtained from:
A. Balkema Publishers, P.O. Box 1675
3000 BR Rotterdam, The Netherlands
URL: http://www.balkema.nl

A. Balkema Publishers
Old Post Road, Brookfield,
VT 05036-9704 USA
email: info@ashgate.com

Seminars/ Conferences/ Events

Odessa 98

Passenger Terminal Building,
Port of Odessa, Ukraine
October 20-23 1998

The Third International Exhibition for Shipping, Shipbuilding, Ports and the Offshore Industries of Ukraine and the Black Sea region will be held in October in Odessa. The exhibit will offer opportunities to view the latest shipbuilding technologies and port equipment, to increase sales to Ukraine and the CIS. It will also focus on short-sea and ferry operations in and around the Black Sea; developing inland waterways and upgrading port handling.

For further information contact:
Odessa 98, Dolphin Exhibitions
112 High Street, Bildeston, Suffolk IP7 7EB, UK
tel. +44 1372 278 411
fax +44 1372 278 412, +44 1449 741 628
telex: 987882 MRM INT G

Marine Port China 1998

Shanghai Exhibition Centre, PR of China
October 27-30 1998

The Sixth International Exhibition for Port and Waterway Construction, Shipbuilding Industry and Transport is being organised by the Hamburg Messe (Germany), the RAI group (The Netherlands) and the Shanghai International Exhibition Corporation (SIECO), with the cooperation of the Chinese Ministry for Transport. Shanghai is the largest seaport in PR China and is in competition with other ports in the Far East. To increase efficiency, plans are being made for the expansion and modernisation of the Chinese trading fleet, to the development and construction of container and other ships, and to extensive projects to improve the infrastructures of the ports and of the hinterlands. The exhibition will provide an important venue for those interested in the growing sea trade with China.

For further information contact:
Hamburg Messe
St. Petersburger Strasse 1
D-20355 Hamburg, Germany
tel. +49 40 3569 2192, fax +49 40 3569 2187
email: hamburgfair@hhmesse.de
http://www.hhmesse.de

Marine Port Vietnam

Ho Chi Minh City International Exhibition
and Convention Centre,
Ho Chi Minh City, Vietnam
November 3-5 1998

Vietnam is strategically located to become an important transshipment centre for the Indochina region and Southeast Asia. With over 3200 km of coastline and more than 11,000 km of inland rivers and canals, the potential for waterborne transportation and shipment is enormous. The government is committed to investing in port development and shipping infrastructure as well as the upgrading and modernisation of its current merchant vessel fleet. Such ports as Hai Phong, Da Nang, Vung Tau, Saigon (the country's largest port), Thi Vai, and Phu My (the first private port), are already being expanded. This exhibition provides an opportunity to take part early on in the rapidly developing Vietnamese maritime industry.

For further information contact:
Singapore RAI, 1 Maritime Square #09-01
World Trade Centre, Singapore 099253
tel. +65 272 2250, fax +65 272 6744

Amsterdam RAI, PO Box 77777
1070 MS amsterdam, The Netherlands
tel. +31 20 549 1212, fax +31 20 646 4469

Hamburg Messe, PO Box 302480
20308 Hamburg, Germany
tel. +49 40 3569 2187, fax +49 40 3569 2187

Expanding Hong Kong

One Great George Street, London, UK
November 5-6 1998

Hong Kong was the site of the worlds' largest single dredging and reclamation project. The new airport was only one of the many infrastructure undertakings, which included dredging for immersed tube tunnels and gas pipelines, the creation of residential and industrial development and the construction of four major container terminals. The experience gathered in executing these projects is invaluable. The conference, oganised by Thomas Telford Conferences on behalf of the CEDA is supported by the Maritime Board of the Institution of Civil Engineers. It will offer a wide range of papers about general strategy, design, execution and environmental effects, which describe how these ambitious and complex projects were successfully completed, often within extremely tight time scales.

For further information contact:
Carol Chin, Thomas Telford Conferences
The Instituion of Civil Engineers
One Great George Street, London SW1P 3AA, UK
tel. + 44 171 665 2316, fax + 44 171 233 1743
email: chin_cice.org.uk

Expo Marítima Mercosur

Centro Costa Salguero,
Buenos Aires, Argentina
November 11-13 1998

The newly developed Expo Marítima Mercosur is being organised by Diversified Expositions, a leading publisher of marine journals including *Workboat Magazine*, and producer of the International Workboat Show. This new event follows on the heels of the recent creation of Mercosur – a free trade zone developed by Argentina, Brazil, Paraguay, Uruguay and associate members Chile and Bolivia. It spotlights the construction of the Hidrovía, the inland waterway system linking the Mercosur countries, and reflects the accelerated investment and interest in this area.
The exhibition will provide an important venue for those involved in port construction, inland waterway development, oil exploration, cargo handling, vessel overhaul and other marine-related industries.

For further information contact:
Diversified Expositions Latin America
121 Free Street, PO Box 7437,
Portland, ME USA 04112-7437
tel. +1 207 842-5500/ fax +1 207 842 5503, or

Diversified Expositions Latin America
Uruguay 1134, 7o, "B"
1016 Buenos Aires, Argentina
tel. +54 1 813 1814, fax +54 1 813 6143

Hydro '99

University of Plymouth, UK
January 5-7 1999

The Hydrographic Society's eleventh international symposium with the theme "Information Management", will deal with a wide range of global issues affecting acquisition, management and presentation of hydrographic data. Topics include: transfer of data sets from vessels via satellite to shore-based processing centres; production of online DTMs; visualisation of land and marine data in four dimensions; data manipulation and presentation for ECDIS and GIS.

In addition to conventional spoken presentations, there will be opportunities for electronic reviews of issues utilising a university computer suite or media such as Internet. The symposium will also be supported by an exhibition of equipment and services.

For further information contact:
Hydro '99, Institute of Marine Studies,
University of Plymouth,
Drake Circus, Plymouth PL4 8AA UK
tel. +44 1752 232410, fax +44 1752 232406
email: hydro99@plymouth.ac.uk

Twenty-eighth Dredging Engineering Short Course

Center for Dredging Studies,
Texas A&M University, Texas, USA
January 11-15, 1999

The Center for Dredging Studies, Civil Engineering Department, in cooperation with the Office of Professional Development at Texas A&M University has created a broad and intensive course on dredging which will include a mixture of lectures, laboratories and discussions.

Two textbooks and course notes on all lectures will be provided. Classes will be held at the Center for Dredging Studies and Hydromechanics Laboratories. The application deadline is December 15, 1998 and the course fee is $1200.

For further information contact:
Texas A&M University
Ms Joyce Hyden,
tel. +1 409 845 4515,
email: j-hydentamu.edu or

Dr RE Randall (Director),
tel. +1 409 845 4568
email: r-randalltamu.edu
fax +1 409 862 8162

Marine Indonesia '99

Jakarta International Exhibition Centre, Indonesia
April 21-24 1999

The 10th International Marine, Shipping, Port Equipment and Cargo Handling Exhibition will be held in Kemayoran, Jakarta, and is the leading exhibition in support of the Indonesian Maritime Industry. Strategic port development for ferry ports and container terminals are a top priority and expansion of inter-island ferries, jetfoils and leisure craft are planned.
The show is suitable for suppliers of all sorts of marine equipment, and port, harbour and navigation technology.

For further information contact:
Marie Waters, Overseas Exhibition Services Ltd
11 Manchester Square
London W1M 5AB UK
tel. +44 171 486 1951, fax +44 171 413 8222
email: indo@montnet.com
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2 Handy Road
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Monalisa Zen, PT Parmerindo Buana Abadi
Unit 2102, 21st Floor
Jl Imama Bonjol 61
Jakarta 10310, Indonesia
tel. +62 21 325 560
fax +62 21 330 406

Call for Papers

Coastal Structures '99

Royal Palace of the Magdalena, Santander, Spain
June 7-10 1999

Puertos del Estado (State Ports of Spain) and the Universidad de Cantabria are organising a conference co-sponsored by the American Society of Civil Engineers (ASCE). The Conference welcomes papers on all aspects of the design, construction and maintenance of coastal structures, such as: functionality, stabiltiy and reliability; wave and structure interaction; geotechnical aspects; physical modelling and field monitoring; environmental problems associated with structures, and so on.

Five copies of each abstract must be submitted in English by September 30, 1998. Abstracts should be no longer than 2 pages. The final camera-ready paper from accepted authors is due on October 1, 1999. Authors may submit abstracts as an email attachment in Word, WordPerfect or ASCII. Fax copies will not be accepted. Authors will be notified of acceptance by December 1998.

For further information check the homepage of the Coastal Structures 99:
http//www.omniasc.es/aforo/coastal99
or email at: aforo@omniasc.es.

Please send abstracts to:
Prof. Iñigo J. Losada, Secretary, Coastal Structures 99
Ocean & Coastal Research Group
E.T.S.I. de Camnos, Canales y Puertos
AV. De los Castros s/n.
39005 Santander, Spain

12th International Harbour Congress

Technological Institute, Antwerp, Belgium
September 12-16 1999

The Royal Flemish Society of Engineers, Section on Harbour Techniques, is organising a 4-day congress to be held together with the 9th International Harbour Exhibition. The topics will include: Port planning; port infrastructure design; port construction; and port access in offshore, coastal and non-coastal harbours. There will also be a workshop on "Information Data Network – Vessel Traffic System". The congress will be followed by the 4th International CATS Congress from September 15-17, 1999 on the Characterisation and Treatment of Sediments.
Interested authors should send a copy of a 300-word abstract of their paper in English to the Secretariat by October 1, 1998. Only original papers describing new work will be accepted. Authors will be notified before November 15, and will then receive instructions for the preparation of their papers. The final version must be camera-ready by April 1, 1999.

Abstracts may be sent using FTP software, "ftp.ti.kviv.be" as user "ti_ftp" and use as password "no". As remote directory fill out ""/ti_ftp/conferences/have/"". Abstracts may also be faxed or mailed (but not emailed).

For further information contact:
12th International Harbour Congress
Att: Ms Rita Peys
c/o Technologisch Instituut vzw
Desguinlei 214, B-2018 Antwerp, Belgium
tel. +32 3 216 0996, fax +32 3 216 0689
email: have@conferences.ti.kviv.be
http://www.ti.kviv.be/conf/have.hmt

CATS 4

Technological Institute, Antwerp, Belgium
September 15-17 1999

The Fourth Congress on Characteristation and Treatment of Sediments (CATS 4) is organised by the Technological Institute of the Royal Flemish Society of Engineers, Sections on Environmental Technology and Harbour Techniques. The congress will be preceded by the 12th International Harbour Congress (September 12-16).

Topics will include: Sediment and dredged material characterisation; source control and sediment management; dredging technology, focussing on contaminated sediments; sustainable relocation and beneficial use; treatment and disposal technologies; environmental risk and environmental merits analysis; impact assessment, management and control; and strategies for sustainable management.

Interested authors should submit two copies of their abstract (1 page) in English by October 1, 1998. Authors will be informed by November 15, and the camera-ready paper is due on April 1, 1999. Abstracts may be sent using FTP software, "ftp.ti.kviv.be" as user "ti_ftp" and use as password "no". As remote diretory fill out ""/ti_ftp/conferences/cats/"". Abstracts may also be faxed or mailed (but not emailed).

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CATS 4
Att: Ms Rita Peys
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Desguinlei 214, B-2018 Antwerp, Belgium
tel. +32 3 216 0996, fax +32 3 216 0689
email: cats@conferences.ti.kviv.be
http://www.ti.kviv.be/conf/cats.hmtCall for Papers

WEDA XIX

Galt Hotel, Louisville, Kentucky, USA
May 15-20 1999

This is the first call for papers for WEDA XIX Annual Meeting and Conference and the 31st Texas A&M Dredging Seminar (TAMU 31). The theme of his three-day technical programme and exhibition is "Environmental and Beneficial Aspects of Dredging". Interested authors should mail their one page abstract before October 15, 1998 to one of the contact persons listed below. Authors will be notified by December 1, 1998 and final manuscripts must be submitted by March 1, 1999.

Please contact the WEDA Technical Papers
Dr Ram K. Mohan, Chair, Gahagan & Bryant Associates
9008-0 Yellow Brick Road, Baltimore, MD 21237 USA
tel. +1 410 6682 5595
email: rkmohanaol.com

Dr Robert E. Randall
Center for Dredging Studies, Texas A&M University
College Station, TX 77843-4568 USA
tel. +1 409 845-4568
email: r-randalltamu.edu

Ms Carol M. Sanders, Sanders & Associates
218 Main Street, Suite 273
Kirkland, WA 98033
tel. +1 425 828 8998
email: saisai.seanet.com

Øresund Link Dredging & Reclamation Conference

Copenhagen, Denmark
May 26-28 1999

Organised by Øresundskonsortiet and CEDA, the aim of the conference is to disseminate information on the construction of the Øresund Fixed Link, one of Scandinavia's largest investments in infrastructure. This 16 km long coast-to-coast motor- and railway linking Denmark and Sweden comprises an artificial peninsula, a 4-km immersed tunnel, a 4-km artificial island and an 8-km bridge. Approximately 8 million m^3 has been dredged and all dredged seabed material has been reused.

All presentations are by invitation, with speakers drawn from the Øresundskonsortiet, the project owner, and the authorities, contractors, consultants and research intstitutes involved. However, the conference will be supported by poster papers. Prospective authors should submit 300-word abstracts in English, no later than 30 September 1998. Completed manuscripts, no longer than 2000 words, will be required by 20 December 1998. Camera-ready papers will be requested by 28 February 1999. Poster authors will be expected to attend the conference and pay the appropriate registeration fee.

For further information please contact:
Organising Committee, Øresundskonsortiet
Kastruplundgade 20-22
DK-2770 Kastrup, Denmark
tel. +45 33 41 6300, fax +45 33 41 6308
email: tunneloresundskonsortiet.dk
Web: www.oresundskonsortiet.com

Membership List IADC 1998

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Boskalis Togo Sarl., Lomé, Togo
Boskalis Westminster Cameroun Sarl., Douala, Cameroun
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Norham/Dragagens, Rio de Janeiro, Brazil
Stuyvesant Dredging Company, Metairie, LA, USA
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Ballast Nedam Malaysia Ltd., Kuala Lumpur, Malaysia
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Boskalis Taiwan Ltd., Hualien, Taiwan
Dredging International Asia Pacific (Pte) Ltd., Singapore
Dredging International N.V., Hong Kong
Dredging International N.V., Singapore
Far East Dredging Ltd., Hong Kong
HAM Dredging (M) Sdn Bhd, Kuala Lumpur, Malaysia
HAM East Asia Pacific Branch, Taipei, Taiwan
HAM Hong Kong Office, Wanchai, Hong Kong
HAM Philippines, Metro Manila, Philippines
HAM Singapore Branch, Singapore
HAM Thai Ltd., Bangkok, Thailand
Jan De Nul Singapore Pte. Ltd., Singapore
Mumbai Project Office, Mumbai, India
PT Penkonindo, Jakarta, Indonesia
Tideway DI Sdn. Bhd., Selangor, Malaysia
Van Oord ACZ B.V., Dhaka, Bangladesh
Van Oord ACZ B.V., Hong Kong
Van Oord ACZ B.V., Singapore
Van Oord ACZ Overseas B.V., Karachi, Pakistan
Zinkcon Marine Malaysia Sdn. Bhd., Kuala Lumpur, Malaysia
Zinkcon Marine Singapore Pte. Ltd., Singapore

Middle East

Boskalis Westminster Al Rushaid Ltd., Dhahran, Saudi Arabia
Boskalis Westminster M.E. Ltd., Abu Dhabi, UAE
Dredging International N.V., Middle East, Dubai
Dredging International N.V., Tehran Branch, Tehran, Iran
Gulf Cobla (Limited Liability Company), Dubai, UAE
HAM Dredging Company, Abu Dhabi, UAE
HAM Saudi Arabia Ltd., Damman, Saudi Arabia
Jan De Nul Dredging, Abu Dhabi, UAE
Van Oord ACZ Overseas BV., Abu Dhabi, UAE

Australia

Condreco Pty. Ltd., Sydney, NSW, Australia
Dredeco Pty. Ltd., Bulimba, QUE., Australia
New Zealand Dredging & General Works Ltd., Wellington
Van Oord ACZ B.V., Victoria, Australia
WestHam Dredging Co. Pty. Ltd., Sydney, NSW, Australia

Europe

ACZ Ingeniører & Entreprenører A/S, Copenhagen, Denmark
Anglo-Dutch Dredging Company Ltd., Beaconsfield, United Kingdom
A/S Jebsens ACZ, Bergen, Norway
Atlantique Dragage S.A., Nanterre, France
Baggermaatschappij Boskalis B.V., Papendrecht, Netherlands
Baggermaatschappij Breejenbout B.V., Rotterdam, Netherlands
Ballast Bau und Bagger GmbH, Hamburg, Germany
Ballast Nedam Dredging, Zeist, Netherlands
Ballast Nedam Dragage, Paris, France
Boskalis Dolman B.V., Dordrecht, Netherlands
Boskalis International B.V., Papendrecht, Netherlands
Boskalis Oosterwijk B.V., Rotterdam, Netherlands
Boskalis Westminster Aannemers N.V., Antwerp, Belgium
Boskalis Westminster Dredging B.V., Papendrecht, Netherlands
Boskalis Westminster Dredging & Contracting Ltd., Cyprus
Boskalis Zinkcon B.V., Papendrecht, Netherlands
Brewaba Wasserbaugesellschaft Bremen mbH, Bremen, Germany
CEI Construct NV, Afdeling Bagger- en Grondwerken, Zele, Belgium
Delta G.m.b.H., Bremen, Germany
Draflumar SA., Neuville Les Dieppe, France
Dragados y Construcciones S.A., Madrid, Spain
Dravo S.A., Madrid, Spain
Dredging International N.V., Madrid, Spain
Dredging International N.V., Zwijndrecht, Belgium
Dredging International Scandinavia NS, Copenhagen, Denmark
Dredging International (UK), Ltd., Weybridge, United Kingdom
Enka-Boskalis, Istanbul, Turkey
Espadraga, Los Alcázares (Murcia), Spain
HAM Dredging Ltd., Camberley, United Kingdom
HAM, dredging and marine contractors, Capelle a/d IJssel, Netherlands
HAM-Van Oord Werkendam B.V., Werkendam, Netherlands
Heinrich Hirdes G.m.b.H., Hamburg, Germany
Holland Dredging Company, Papendrecht, Netherlands
Jan De Nul N.V., Aalst, Belgium
Jan De Nul Dredging N.V., Aalst, Belgium
Jan De Nul (U.K.) Ltd., Ascot, United Kingdom
Nordsee Nassbagger- und Tiefbau GmbH, Wilhelmshaven,Germany
N.V. Baggerwerken Decloedt & Zoon, Brussels, Belgium
Philipp Holzmann Aktiengesellschaft, Hamburg, Germany
S.A. Overseas Decloedt & Fils, Brussels, Belgium
Sider-Almagià S.p.A., Rome, Italy
Skanska Dredging AB, Gothenborg, Sweden
Sociedade Portuguesa de Dragagens Lda., Lisbon, Portugal
Sociedad Española de Dragados SA., Madrid, Spain
Società Italiana Dragaggi SpA. "SIDRA", Rome, Italy
Société de Dragage International "S.D.I." S.A., Marly le Roi, France
Sodranord SARL, Paris, France
Tideway B.V., Breda, Netherlands
Van Oord ACZ B.V., Gorinchem, Netherlands
Van Oord ACZ Ltd., Newbury, United Kingdom
Van Oord ACZ B.V., Zwijndrecht, Belgium
Volker Stevin Baggermaatschappij Nederland B.V.,Rotterdam, Netherlands
Volker Stevin Dredging B.V., Rotterdam, Netherlands
Wasserbau ACZ GmbH, Bremen, Germany
Westminster Dredging Co. Ltd., Fareham, United Kingdom
Zanen Verstoep B.V., Papendrecht, Netherlands
Zinkcon Contractors Ltd., Fareham, United Kingdom
Zinkcon Dekker B.V., Rotterdam, Netherlands
Zinkcon Dekker Wasserbau GmbH, Bremen, Germany

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