OFEL
630

ADDED VALUE OF INTEGRATED BRIDGE SYSTEMS FOR SHORE APPLICATIONS

René R. Hol B.Sc. and Wim F.M. van der Heijden B.Sc. Eur.Ing.

TNO PHYSICS AND ELECTRONICS LABORATORY (TNO-FEL)
Mobile & Satellite communication department
Section: Navigation & Identification
PO Box 96864, 2509 JG The Hague
The Netherlands
Tel. +31 70 3740335, Fax +31 70 3740653
E-mail: Hol@fel.tno.nl, vanderHeijden@fel.tno.nl

Abstract

As a result of fast developments in information and communication technology and the trend to reduce costs, the way of operating modern vessels will change. The introduction of integrated bridge systems contributes to solving the problem of the different 'islands of information' as can be seen in the present situation.

The main objective of integrated bridge systems aboard of both naval and merchant vessels is to use common data from different origin. Data obtained by one function to operate the vessel should be made available for others. Integration prevents duplication of sensors and decreases the workload of the crew. Even more important, integration increases safety of operation due to, among others, the transition of manual to automatic processing and the introduction of decision support systems.

The availability of common data is also important for the logistic process and typical shore applications as vessel traffic management and shore based pilotage. A vessel is sailing to transport cargo in order to fulfil a part of the intermodal transport chain. Optimising this chain will require real-time information from the vessels at the shore. Also the transition of Vessel Traffic Services (VTS) to Vessel Traffic Management and Information Systems (VTMIS) requires additional information.

It is clear that integrated bridge systems provide an added value for shore applications. To take advantage of this fact it is essential to apply new developments in communication technology (e.g. transponders) in order to exchange data between ship and shore.

The paper describes the functional ideas of the Bridge2000 project with regard to the added value for the shore. The Bridge2000 project is a study, aiming to integrate information of several subsystems and to define human interfaces.
Furthermore, international developments related to ship-shore communication and shore applications will be briefly presented in the paper. Topics include integrated bridge systems, developments in communication technology, transponders and shore applications.

1. Introduction

Significant progress has been made in ship control. New ships built have some form of integrated ship control. Integrated ship control can be characterised by all computers in the control system being able to interchange information. This concept has in it a potential for making a control system better and safer, mainly due to the increased availability of important information. Integration prevents duplication of sensors and decreases the workload of the crew. Even more important, integration increases safety of operation due to, among others,

TNO
26440

the transition of manual to automatic processing and the introduction of decision support systems.

The availability of common data is also important for the logistic process and shore applications. Vessels are not sailing because the master or the owner likes it. They are sailing for handling goods or to observe the ocean in case of a navy vessel. Not the sailing itself is important, but the transport chain in the logistic process or the operational task. Maritime transport is only one part of the total logistic chain. In order to enhance transport efficiency, advanced information and communication technologies need to facilitate intermodal transport, port efficiency and electronic navigation guides. The main goal, however, is to achieve faster handling of goods so that transport time as a whole is reduced.

One important aspect with regard to enhancement of transport efficiency and safety is the information exchange between ship and shore. Data originating from vessels is required for shore applications in order to make transport safe and efficient. Most commonly known is the exchange of information between a VTS (Vessel Traffic Service) and vessels entering a harbour. In the present situation, this shore application requires at least identity, position and intention information. Apart from this more or less traditional ship-shore communication current trends can be derived in the maritime transport with regard to future applications. A brief description of future applications which could benefit from integrated bridges, is given in this paper.

A condition needed to gain advantage of common data from vessels, is the availability of integrated bridge systems and ship-shore communication. In this paper the Bridge2000 project will be addressed. The Bridge2000 project is a study, aiming to integrate information of several subsystems on board and to define human interfaces. The paper will also discuss the developments in mobile and satellite communication applicable for future applications.

2. (Future) shore applications

As a result of research studies and more stringent requirements regarding safety and efficiency, a number of new applications must be taken into account. The introduction of these applications are not limited to the vessel itself. New applications are foreseen requiring automatic exchange of information between ship and shore and integrated bridge systems.

The following future applications are recognised:

1. **Vessel Traffic Service and identification.** The International Maritime Organisation (IMO) is developing standards and guidelines for the application of transponders for vessel monitoring. Present systems are mainly used for automatic identification and positioning to verify radarsignals and to increase the ability to distinct radar targets. Operators are able to interrogate a specific vessel or an area with vessels. Vessels equipped with transponders will answer the interrogation with their position, actual course, speed and other relevant information. Apart from automatic identification, transponders can help VTS systems to prevent 'melting' of radar targets and lost targets. This application increases the reliability of the traffic image and lowers the work pressure of operators. TNO-FEL developed a transponder system called "Automatic Reporting and Identification System" (ARIS) [1], [2]. With ARIS, several trials are executed to study the feasibility of automatic identification within harbours and to prevent 'label lost' and 'label swapping' of radar targets.

2. **Shore Based Pilotage.** Advising vessels entering a harbour from shore is an application under development. The requirements for shore-based pilotage have been investigated in the EURET project that was part of the 3rd Framework Programme of the EC [4].
3. **Information gathering in case of environmental accidents or other emergencies.** The Dutch Coast Guard's main task is to prevent calamities and to co-ordinate search and rescue activities. There is a need for information from vessels and their cargo in case accidents occur or during search and rescue operations. Reliable ship-shore communication and common data are required.
4. **Preventive monitoring of vessels.** Shore authorities need to have an ability to check whether ships are sailing according the international rules. They want to monitor separate traffic lanes, specifically for those ships carrying dangerous cargo. Vessel monitoring is currently provided by radar-based systems, which have limited geographical coverage. Proposals and specifications are under development for a long range vessel monitoring system that will be able to monitor movements of vessels at open sea (wide area transponder) [5].
5. **Cargo-flow management and cargo monitoring (tracing and tracking).** Information from vessels is essential for the efficient planning and co-ordination of inland transport with sea transport (intermodal transport). The availability of data and efficient ship-shore communications can enable an efficient planning of the internal port functions, and thus could guarantee that the call of the ship will be minimised to a specified time period. Monitoring the condition of the cargo is of great importance to the quality control of the cargo or even the environment. Measuring the conditions is possible on a local base but the owner of the cargo may also be interested in the condition of the cargo.
6. **Remote diagnostics and maintenance.** The growing complexity of systems requires a number of specialists to solve problems. On the other hand, the quality and reliability of systems are increasing, which reduces the continuous need for well-educated personnel on board with knowledge of maintenance and repair. Expert systems to solve many problems will be installed on board . However, with the reduction of the crew and in spite of the introduction of expert systems, the knowledge to solve the most difficult and complex problems will disappear from the vessel. Ships require support from remote experts or interaction with distant collaborators in various application cases.

Requirements for future applications

Future requirements will be based on, and will need to support the above mentioned applications. The most important requirements are:

1. the integration of vessel monitoring information, vessel and cargo control information and safety information for an efficient land-side based intermodal transport planning and management system;
2. the integration of land-based information with vessel-based information for an optimal operational efficiency.

There are several ongoing developments to fill in these requirements.

Ad. 1) Due to various emerging technologies, the perception of VTS has changed over the years from an aid to navigation to a much more comprehensive system. VTS is now recognised as a service capable of contributing substantially to the safety of life and the protection of the environment, as well as the efficiency of our waterways. This evolution of VTS is at a crossroad of seeing the realisation of a service capable of interacting with vessel traffic as well as with port industry and authorities. Research and development in the field of this new VTMIS (Vessel Traffic Management and Information Service) are carried out within the 4th Framework of the European Committee DGVII.

Ad. 2) Integrated bridge systems will improve efficiency of ship operations, increase safety and reduce operational expenses of fleet owners. Integrated bridge systems will also provide an added value for shore applications. The developments in bridge integration will have considerable influence on the progress in developments towards the integration of land-based and vessel-based information. Chapter 4 addresses the ongoing developments in the field of bridge integration. The added values of bridge systems cannot be addressed without the use of sophisticated communication means. The developments in this field are briefly described in the next chapter.

3. Developments in communication

Present communication is based on terrestrial communication means. VHF, HF, MF frequencies are used for ship-ship and ship-shore communication. In the last decade, maritime transport has been using Inmarsat satellite communication for mainly ship-shore communication and for safety reasons within the Global Maritime Distress and Safety System (GMDSS).

Both in freight transport and in passenger transport, the trend towards development of intermodal, door to door, service is one of the most important issues. This development of intermodal services, together with the enlargement of ships, is the most imperative development in the maritime industry. In this development process towards new intermodal transport services, communication systems will be of significant value for the exchange of information concerning vessels and their cargo.

Information and data exchange in ship-shore communication are under development and are seeing some rapid implementation. In stead of ships operating as stand alone systems, satellite and cellular data links are being used to create integrated ship management systems. Information to and from the port authorities and corporate office is exchanged by email, fax and EDI over radio communication links. The information exchange is used to provide and receive data on different types of applications as described in chapter 2. Depending on the application, the size of the data may vary. The amount of information required for remote diagnostics and maintenance of ship facilities can be very large, whereas identification and position messages can be relatively small. This means that some future applications require high speed data exchange with data rates of 64 kbps or higher over satellite links, while others can be satisfied with relatively low data rates over terrestrial communication links.

Satellite communication
From a perspective view of present developments in satellite communication we can be certain that commercial satellite communication will show a shift from geostationary systems to low or medium orbit systems. The satellites of these LEO (Low Earth Orbit) and MEO (Medium Earth Orbit) systems are placed in a relatively low orbit to earth, which consequently results in a few advantages compared to geostationary constellations (using high orbits like Inmarsat).

- The satellite as well as the ground equipment can suffice with a low transmitting power and less sensitive receivers. This has the advantage that satellites and ground equipment can be kept small and relatively cheap.
- The transmission delay of LEO-systems is remarkably less compared to geostationary systems. This is certainly important for voice communication where delay can be inconvenient for the user. In case of data communication it appears that too much delay causes less data throughput or loss of data.
- A lot more satellites are required in a LEO system to sustain to a comparable coverage area. This has, however, the advantage that LEO-systems are less sensitive for

malfunctioning of one satellite. The function of a defect satellite will be taken over by a satellite in the same orbit.

- LEO-system consist of many satellites with a relatively small coverage area which means that transmit frequencies can be reused. This has the advantage that LEO-systems are efficient in terms of frequency spectrum and communication capacity.
- LEO and MEO systems are rather simple with respect to functionality and design compared to GEO-systems, which means that communication via a LEO or MEO system will probably costs less than communication via a GEO-system. Furthermore, the implementation of several LEO and GEO systems will result in a competitive market between providers, which will result in a decrease of cost of air-time.

Table 1 depicts an overview of some communication systems which are expected to be introduced in the near future.

Table 1: Overview of future satellite networks

SYSTEM NAME	ORBIT/ NUMBER OF SAT.	YEAR DEPLOY/ OPERATIONAL	SERVICES	COVERAGE
GLOBALSTAR	LEO / 48	1997	voice, data (9.6 kbit/s)	between 70°N and 70°S
IRIDIUM	LEO / 66	1998	voice, data (2.4 / 4.8 kbit/s)	world-wide
ORBCOMM	LEO / 36	1995 / 2000	data, 2-way messaging, positioning	world-wide
ICO	MEO / 11	2000	voice, data (4,8 kbit/s)	world-wide
TELEDESIC	LEO / 840	2002	broadband (2 Mbit/s)	world-wide
INMARSAT-P	MEO / 12	1998 / 2000	voice,data, fax, positioning	world-wide

We will not describe above systems in this paper. The reader is referred to the literature [5, 6].

Terrestrial communication

In terms of terrestrial communication, VHF takes care of most maritime communication traffic today. VHF is used within harbours, harbour approaches, coastal areas and inland traffic. Present transponder systems are also based on VHF-communication. MF and HF communication are used within the maritime transport sector for shore based services, basically with regard to safety in the GMDSS.

GSM (Global Service for Mobile communication) is becoming popular as a means of radiotelephony. Cellular services like GSM are well suitable for voice and data communication on land. If the infrastructure is well designed it can also be used for inland rivers and small lakes. At first glance these systems appear not to be suitable for maritime communication. On the other hand we have to consider trends as mixed traffic in harbour areas and short sea shipping. It is well thinkable that for applications described in chapter 2, cellular systems are used, if necessary in combination with other cellular or satellite systems.

Combining of systems is one of the most important features of future communication systems. Interoperability of cellular systems with satellite systems is taken into account in the specification and development of future systems.

At present two mobile communication networks that can be pointed out as the 3rd generation mobile communication systems are under development . These are the Universal Mobile Telecommunication System (UMTS) and the Future Public Land Mobile Telecommunication

System (FPLMTS). Both are in the standardisation phase within the ITU and ETSI. Some examples of services are voice, facsimile, video telephony and multimedia services. The datarates may vary from 16 kbit/s up to 2 Mbit/s. Both systems have the objective to provide their services to users word-wide. UMTS and FPLMTS will become interoperable with other communication systems. This means that user equipment can use different systems without being noticed by the user (global roaming). For world-wide coverage satellite systems need to be interoperable with cellular systems. Iridium and Globalstar will probably fulfil this function. Geostationary systems like Inmarsat can also be used.

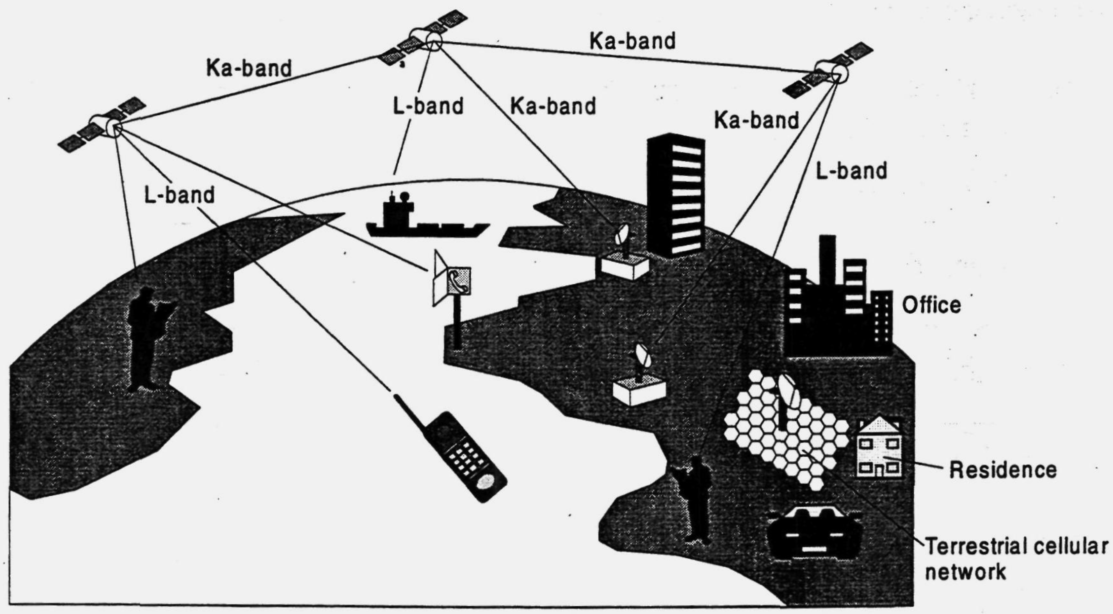

Figure 1: Iridium satellite communication system

4. Bridge integration

Brug2000 [7]
Several international developments are going on regarding bridge integration. This paper discusses the value of these developments for shore applications and will not describe integrated bridge developments in detail. However, we like to make attention to the Bridge2000 project, a Dutch research project. This project is undertaken by three parties headed by TNO Physics and Electronics Laboratory (TNO-FEL). The other institutes are the Royal Netherlands Naval College (KIM) and TNO Human Factors Research Institute (TNO-TM).

Bridge2000 is a study and pilot project for fully integrated vessel systems. The intention of the project is to bring navigation systems, platform systems, ship management systems and communication systems together in one open network structure and to define the human interfaces. Only in this way we will get a fully integrated bridge system, not limited to physical integration, but electronically integrated. The system architecture of the Bridge2000 concept will make it possible that information from all the systems on board can be used by other systems, not only on board but also on the shore. The advantage of the Bridge2000 concept is that it reduces the installed amount of equipment (all the systems can use all sensor information), it reduces data and verbal communications, it reduces the task of the crew (automatic data interchange) and it can reduce the task of a number of organisations on the shore (by automatic gathering and distributing of information). The human-machine relation in such a concept is very important.

Functions

Within Bridge2000 we distinguish four main functions: navigation, platform control, vessel management, and communication. These functions can be carried out manually but with help of modern techniques the task load of the crew can be decreased while at the same time the quality and accuracy are being increased.

Modern aids are available to fulfil the navigation function. Today, not the estimated but the real position, speed and course are important in terms of 'just in time' planning and accurate and safe navigation. Modern navigation systems on board have at least one radio-navigation based positioning system (DECCA, LORAN-C, GPS, GLONASS or other satellite based system) and of course the classic navigation instruments (compass, log, gyro, radio direction finder, etc.). For a safe navigation there is also a radar system on board with an ARPA facility. All navigation functions are carried out on the bridge.

The second main function on board is the control of the platform systems. This is the propulsion, steering, stabilisation, fresh water installation, ventilation, etc. In fact, it is every system installed to sail and maintain the condition of ship and crew. The platform control function can be carried out in the machine control room but distributed control is also possible.

Vessel management applies more to the administrative work on board. Information about cargo and or passengers, crew, supplies, etc. are all belonging to the vessel management function. Trip preparation in terms of ports of destination, agents, facilities, etc. can also be part of vessel management.

Two communication functions may be distinguished 1) internal communication and 2) external communication. Internal communication is defined by the communication between the functions and systems on board for data exchange and the common use of sensors and facilities. External communication is defined as the communication with the outside world. This includes VHF, HF and satellite communication. GMDSS and transponder functions, using the communication means, will be included during the next coming years. Chapter 3 described the developments within this field and the importance to integrate ship systems with shore systems.

RINAC

The technologies and principles from the Bridge2000 project are also applicable for inland navigation. Integration of the communication function and the other main functions as given before will give new opportunities for inland navigation vessels. RINAC (River Based Information, Navigation and Communication), a project of the 4th Framework Programme of the EC, deals with this development to increase safety and efficiency in navigation and logistics. Typical developments are:

- electronic charts for inland navigation (Inland Navigation Geographical Information System INGIS);
- transferring tactical traffic images to vessels in order to increase safety;
- better calculation of ETA's for, among others, lock planning and connecting transport;
- transponders for identification and reporting.

Further detailed description of this project is outside the scope of this paper. The reader is referred to the RINAC WWW homepage [8].

5. Added value of integrated bridge systems for shore applications

Above all, bridge integration was discerned as essential to navigational safety. It is now generally accepted that bridge integration brings cost savings and at the same time enhances safety. Furthermore, bridge integration can be used for transferring information to those places where it is needed. The integrated bridge allows automatic retrieval and dispatch of any needed information between ship and shore. Information can be gathered, among others, from sensors, the navigation system, the voyage management system or the steering control system. On initiation from shore or other ship, the contents of electronic mail boxes can be exchanged over satellite links. This improvement over standard communication packages can significantly reduce costs, as all sign-on procedures can be accomplished automatically.

In chapter 2 we described a few future shore applications or services. The added values of an integrated bridge system with respect to these applications are here described.

Vessel Traffic Service and automatic identification
If a vessel approaches a VTS area there is a mandatory duty to report its position, identification, destination, etc. to the VTS operator. Normally this will be done by voice communication but the use of transponders [2, 3] is in discussion. Applying transponder technology for VTS has advantages for automatic identification and gathering of additional information as actual draught, destination, ETA, etc. without verbal communication with the crew. Because a transponder system on board needs variable information as draught, destination, ETA, course and speed this communication system has to be connected to the sources where this information is available. An integrated bridge system is able to provide this information.

Shore based pilotage
A shore-based pilot requires at least the (electronic) routeplan from the vessel. Beside the intention of the vessel additional information is required for a safe advice to the vessel. Ship information, such as rudder position, draught, rate of turn, etc. as well as information about the vessel's vital systems must be collected and transmitted to the shore to serve the pilot. This next to the information about position, speed, course and the local conditions as weather, currents, and the local traffic image. It is clear that only an integrated bridge system including the communication function can fulfil these requirements.
Furthermore, advises from the shore can be automatically transferred without using voice communication to the vessel. In this case an integrated bridge system is able to present shore advises to the crew at any place on board and is able to provide confirmation services to the crew.

Preventive monitoring of vessels.
Proposals and specifications are under development for a wide area vessel monitoring system, which will be able to monitor movements of vessels at open sea [5]. This Wide area Reporting and Identification System (WARIS) requires at least information concerning the identity, position and common data concerning the cargo of the interrogated vessel. A WARIS transponder needs information from the navigation system, propulsion and cargo monitoring system. It is clear that, apart from automatic ship-shore communication, an integrated bridge will help to facilitate transponders on board.

Cargo-flow management and monitoring
A ship is part of the logistic chain for transporting goods. Detailed information from the ship is required for an efficient planning and co-ordination of port facilities. At least a routeplan, actual position and possible delay with respect to the estimated time of arrival are required. In case of cargo monitoring detailed information of the condition of the cargo (air-conditioning, humidity) is of great importance to the quality control of the cargo. If the measured values of the cargo are stored in a cargo monitoring system, which is subsequently connected to the integrated bridge system, it will be possible for the owner to access the desired information in order to control the situation on board.

Remote diagnostics and maintenance
The growing complexity of systems requires a number of specialists to solve problems. Assistance will be required from experts on the shore to solve those very complex problems. Remote diagnostics and technical support in maintenance and repair of equipment on board ships are only possible with integrated bridge systems. In this way experts are able to 'look' into all the systems without being on board, whether it is a platform system or a navigation system. With help of (broadband) multimedia communication with data, video and audio combined, expertise is virtually always available world-wide.

6. Conclusions

This paper describes future shore applications that require a sophisticated ship-shore communication and integrated bridge systems.

An integrated bridge is a bridge in which communication between the various navigation aids, instruments and displays can take place and makes it possible to concentrate large amounts of information at one place. Data can be made available for each on board function and therefore will reduce equipment and sensor systems as opposed to gathering the information from each stand-alone system. As a consequence of rapid developments in the field of integrated bridges, communication technology and requirements from shore services, information exchange between ship and shore will grow extensively. New services require common data from vessels sailing at any place and time in the world. The added value of integrated bridge systems for shore based services is the availability of common data for shore services.

There are several ongoing research and development projects in the field of bridge integration. This paper described the Bridge2000 project, a Dutch initiative. The intention of the project is to bring navigation systems, platform systems, ship management systems and communication systems together in one open network structure and to define the human interfaces.

With regard to satellite communications, a further growth in the implementation of satellite telephony systems for public correspondence is foreseen. Today, satellite communication is only a relatively small part of the total communication pattern for operational ship-shore communication. This is mainly due to the high costs of equipment and used communication time. The expected future expansion of (LEO) satellite systems for communication purposes (voice and data), and the expected reduction of communication and user equipment costs, will contribute to the growth of voice and data exchange via satellites for some of the described applications. However, we have to take into account that a part of maritime services, certainly those related to tactical safety information, require a point to multipoint mode, constant availability and reliable connections. When these aspects are taken into account, new communication technologies might be attractive as an additional network in certain maritime applications, but probably not as an alternative.

The further development of cellular communication services will certainly have an impact on the usage of radiotelephony in inland waterway transport and possibly also in short sea shipping and coastal transport. Major growth is expected in cellular digital communication. However, it is recognised that present cellular communication is inappropriate for ships trading internationally. These ships need a global communication service. Future cellular communication systems will incorporate interoperability with other systems and satellite communication, which will result in global coverage.

7. References

[1] Automatic Reporting and Identification System ARIS: Development and evaluation, T.A. Knoester, Ing. J.H.A. Schoenmaker, Dutch TNO-rapport FEL-90-C026, January 1990

[2] Trials with the Automatic Reporting and Identification System (ARIS-transponder) in co-operation with the Schelde Radar Chain, T.A. Knoester, Ing. J.H.A. Schoenmaker, Ing. G. Witter, Dutch TNO-report FEL-94-C038, March 1994

[3] Transponder system feasibility tested in Scheldt VTMS in Antwerp, Proceedings of the International Maritime Conference 'The impact of new technology on maritime industries', Southhampton, September 1993

[4] Shore-Based Tactical Advice/Shore-Based Pilotage Step 6: Conclusion, J.M.C. Schraagen, W.F.M. van der Heijden, R.R. Hol, C.Z. Mensch, TNO-report TM-1994 C-8, EURET TAIE project

[5] Feasibility study 'Wide area Automatic Reporting and Identification System', R.R. Hol, R.A. Gutteling, Dutch TNO-report, commissioned by Ministry of Transport

[6] Mobile Communication Satellites, Tom Logsdon, McGraw-HILL Inc., ISBN 0-07-038476-2

[7] Bridge2000 project, WWW-homepage http://www.tno.nl/instit/fel/brug2000/

[8] River Based Information, Navigation and Communication, Project within the 4^{th} Framework of the EC DGVII, WWW-homepage http://www.tno.nl/instit/fel/rinac/

PROGRAMME AND PAPERS

9th World Congress of the International Association of Institutes of Navigation

18 - 21 November 1997

AMSTERDAM THE NETHERLANDS

Under the auspices of

IAIN

Organized by
NETHERLANDS INSTITUTE OF NAVIGATION

Sponsored by

THE NETHERLANDS MINISTRY OF TRANSPORT, PUBLIC WORKS AND WATERMANAGEMENT
Directorate General for Freight Transport

CHARTCO
ChartCo

AMSTERDAM RAI
Amsterdam RAI International
Exhibition and Congress Centre