DESIGN, DEVELOPMENT AND TESTING
OF A
MARITIME NAVIGATION SYSTEM

Prepared for
Transportation Development Centre
Safety and Security
Transport Canada

May 1997

DESIGN, DEVELOPMENT AND TESTING
OF A
MARITIME NAVIGATION SYSTEM

by
Patrice Piché, eng
Q-MAR Inc.

May 1997

Un sommaire français se trouve avant la table des matières.

	Transport Canada	Transports Canada	**PUBLICATION DATA FORM**

1. Transport Canada Publication No.	2. Project No.	3. Recipient's Catalogue No.
TP 13033E	8353/54	

4. Title and Subtitle	5. Publication Date
Design, Development and Testing of a Maritime Navigation System	May 1997
	6. Performing Organization Document No.

7. Author(s)	8. Transport Canada File No.
P. Piché	ZCD1460-334

9. Performing Organization Name and Address	10. PWGSC File No.
Q-Mar 1801 McGill College Ave. Suite 1000 Montreal, Quebec H3A 2N4	XSD93-00173-(621)
	11. PWGSC or Transport Canada Contract No.
	T8200-3-3541/01-XSD

12. Sponsoring Agency Name and Address	13. Type of Publication and Period Covered
Transportation Development Centre (TDC) 800 René Lévesque Blvd. West 6th Floor Montreal, Quebec H3B 1X9	Final
	14. Project Officer
	A. Taschereau

15. Supplementary Notes (Funding programs, titles of related publications, etc.)
Cofunded by Innovatech.

16. Abstract

This document is a detailed description of the results of research and development into an electronic navigation system designed to make navigation on the St. Lawrence River safer, particularly in winter and during poor weather.

The feasibility of the concept of a new Marine Navigation System (MNS) was demonstrated using an initial model based on an open architecture (personal computer and Windows operating system) incorporating DGPS (Differential Global Positioning System) positioning technology and electronic nautical charts.

Following trials at sea conducted with the help of potential users, MNS software and materials were refined and completed, leading to the production of two configurations of the system, one portable and the other ship-based. One system in each configuration was delivered under the contract.

The innovations brought by the MNS include the availability of a portable version for the pilot, the use and display of real-time water level data, and automatic communication between MNSs.

The results of this research and development have shown that the objectives set initially were met and that the prospects are very good for an MNS as a centre for integrating navigation information.

17. Key Words	18. Distribution Statement
Electronic navigation, electronic charts, Electronic Chart Display and Information System (ECDIS)	Limited number of copies available from the Transportation Development Centre

19. Security Classification (of this publication)	20. Security Classification (of this page)	21. Declassification (date)	22. No. of Pages	23. Price
Unclassified	Unclassified	—	xviii, 136, apps	—

16. Résumé

Ce document décrit en détail les résultats des recherches et développements d'un système de navigation électronique destiné à rendre la navigation sur le fleuve Saint-Laurent plus sécuritaire, surtout l'hiver et par mauvais temps.

Un premier modèle basé sur une architecture ouverte (ordinateur personnel et système d'exploitation Windows) et intégrant les technologies de positionnement DGPS (Differential Global Positioning System), et de cartes maritimes électroniques, a démontré la faisabilité du concept d'un nouveau système de navigation maritime.

Suite à des essais en mer effectués avec la collaboration d'usagers potentiels, les éléments logiciels et matériels du SNM ont été rafinés et complétés pour culminer dans la production de deux configurations du système : l'une portative et l'autre embarquée. Un système de chaque configuration ont été livrés dans le cadre de ce contrat.

Les innovations apportées par le SNM incluent : la disponibilité d'une version portative pour pilote, l'utilisation et l'affichage des données sur les niveaux d'eau en temps réel, et une communication automatique entre SNM.

Les résultats des recherches et développements ont démontrés que non seulement les objectifs fixés initialement ont été atteints, mais que les possibilités du SNM comme centre d'intégration d'information de navigation sont très prometteuses.

ACKNOWLEDEGMENTS

SUMMARY

Navigation on the St. Lawrence river has always been a challenge to mariners. Its limited channel width, lack of navigational aids in winter, ice floe cover during several months of the year, and frequent bad weather, can render the St. Lawrence River a hazardous, often treacherous waterway. The project's objective was the development of a Maritime Navigation System (MNS) that would increase the safety of navigation on the St. Lawrence River, particularly during winter nights, while making the Port of Montreal accessible 365 days a year, 24 hours a day.

The necessary infrastructure to support this project, including Differential Global Positioning System (DGPS) and electronic nautical charts, were put in place just prior to and during the development of the project.

A model was developed to prove the feasibility of the concept. This model was successfully tested in laboratory and real-life environments. Additional prototypes, based on the same model, were assembled and installed on board merchant marine and Coast Guard vessels to be subjected to field trials by potential users. The malfunctions and observations recorded during the field trials led to significant software changes or extensions to the following elements:
- graphical user interface
- route monitoring
- chart loading and display
- real-time water level display

The software was packaged into two different hardware configurations to provide complete solutions to client shipowners : a ship-based configuration for permanent installations, and a fully autonomous pilot configuration for temporary installations requiring quick connect/disconnect capability.

The ship-based configuration was designed around a console featuring a pivoting turret (comprising display monitor, keyboard, and trackball) with a robust locking mechanism. A backlit keyboard with customized keycap legends facilitates operations at night and provides the most common functions on hardware buttons (in addition to software buttons). The pilot configuration was designed as a fully autonomous system retaining most of the ship-based configuration functions, but with a reduced sensor's interface capability. In addition to reduced size and weight, the pilot configuration incorporated a wireless link between the GPS/DGPS receiver and the portable computer. However, extensive research and investigations have not yet yielded an acceptable solution where this wireless link could operate as reliably as the coaxial cable it is to replace, and for long periods of time (18 hours minimum) under extreme temperature conditions.

A study of the feasibility of overlaying the radar image to the electronic chart display revealed that the MNS would greatly benefit from interfacing to a proven, recognized, and mature Radar Scan Converter, as oppose to interfacing to an undesign, unproven, inhouse-developed one. The integration of an interface to a Modular Radar Interface (MRI) was completed; minor problems that arose were effectively resolved.

Final testing of the MNS was successfully conducted on board the Canadian Coast Guard vessel F.C.G. Smith using prototypes of the ship-based and pilot configurations.

Precedents set by MNS-equipped vessels sailing at night during the winter months, indicated that the objective of increasing the safety of navigation on the St. Lawrence River, and rendering the Port of Montreal accessible all year long were successfully met. Furthermore, the marine community has shown an openness to this new technology.

With the advent of specialized applications in the fields of ice navigation, predictive maneuvering, river bottom modeling, etc., it is recommended that development of the MNS be pursued to turn it into a major navigational information integration centre, able to offer the mariner complete navigational data in a comprehensive graphical manner.

SOMMAIRE

Il a toujours été difficile de naviguer sur le Saint-Laurent. L'exiguïté de la voie navigable, l'absence d'aides à la navigation en hiver, la présence de floes de glace plusieurs mois de année et le mauvais temps fréquent rendent la navigation dangereuse, voire traîtresse. La recherche avait pour objet de développer un système de navigation maritime (SNM) qui rendrait la navigation sur ce fleuve plus sûre, surtout durant les nuits d'hiver, et de rendre la port de Montréal accessible l'année durant.

Toute l'infrastructure nécessaire à la mise en œuvre du SNM, à savoir le Système de positionnement global différentiel (DGPS) ainsi que les cartes marines électroniques, était déjà en place, ou l'a été, durant le cours de la recherche.

Pour montrer la faisabilité du SNM, un modèle a été élaboré et testé avec succès en laboratoire et dans des environnements représentatifs de la réalité. D'autres prototypes fondés sur ce modèle ont été assemblés et installés à bord de navires marchands et de navires de la Garde côtière, pour être mis en service par les clients potentiels du système. Les dysfonctions observées durant ces essais ont permis d'apporter des changements ou des prolongements importants aux éléments suivants du système :

- interface graphique opérateur
- suivi de la marche du navire
- chargement et affichage des cartes
- affichage en temps réel de la profondeur d'eau disponible

Le logiciel se présente sous deux configurations distinctes : l'une embarquée donc fixe, l'autre portable avec un moyen de raccordement rapide, dite pilote.

La version embarquée s'articule autour d'une console avec tête pivotante comportant une visualisation, un clavier, une boule roulante et un mécanisme de blocage robuste. Sur le clavier lumineux, les touches nominatives des fonctions permettent un fonctionnement s^r de nuit. On y retrouve la plupart des boutons de fonction tant du matériel que du logiciel. Complètement autonome, la version pilote possède toutes les fonctionnalités de la version embarquée, à l'exception de l'interface aux capteurs autres que le GPS/DGPS. Allégée et de dimensions réduites, cette version assurait une liaison hertzienne entre le GPS/DGPS et l'ordinateur portable. Malgré les recherches poussées, aucune solution acceptable n'a pu être trouvée qui ferait que cette liaison soit aussi fiable que le câble coaxial qu'elle est supposée remplacer, et soit capable de fonctionner sans interruption pendant des heures (18 heures, au moins) dans des conditions de température extrêmes.

L'étude sur la faisabilité de superposer l'imagerie radar sur les cartes électroniques affichées montre que l'efficacité du SNM augmenterait considérablement s'il était interfacé à un convertisseur de coordonnées radar de marque connue et ayant fait ses preuves, plutôt qu'à un qui ne serait ni l'un, ni l'autre. L'intégration d'une interface à l'interface modulaire radar MRI a été achevée et les petites difficultés qui ont surgi ont été rapidement réglées.

L'essai final du SNM s'est déroulé avec succès à bord du F.C.G. Smith de la Garde côtière canadienne, avec les prototypes des configurations embarquée et pilote.

Les expérimentations sur le SNM à bord de navires naviguant de nuit en hiver ont montré que le double objectif d'accroître la sûreté de la navigation sur le Saint-Laurent et de rendre le port de Montréal accessible l'année durant a été réalisé avec succès. Par ailleurs, les milieux du transport maritime se sont montrés intéressés par cette technologie novatrice.

Dans la perspective des utilisations spécialisées dans le domaine de la navigation dans les glaces, telles que le pilotage prédictif, la modélisation des fonds marins, etc., il est recommandé que le développement du SNM soit poursuivi pour en faire un important système d'information intégré pour la navigation maritime, fournissant aux pilotes un jeu complet d'informations dans un format graphique compréhensible.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

GLOSSARY OF ABBREVIATIONS AND ACRONYMS

The following abbreviations and acronyms are used throughout this report:

AIS	Automatic Identification System
ARPA	Automatic Radar Pointing Aid
Bow X	Bow crossing
CCG	Canadian Coast Guard
CHS	Canadian Hydrographic Service
COG	Course Over Ground
COWLIS	Coastal and Ocean Water Level Information System
CPA	Closest Point of Approach
DGPS	Differential Global Positioning System
DTG	Distance To Go
EBL	Electronic Bearing Line
ECDIS	Electronic Chart Display and Information System
EDT	Estimated Departure Time
ENC	Electronic Nautical Chart
ETA	Estimated Time of Arrival
GPS	Global Positioning System
IHO	International Hydrographic Organization
IMO	International Maritime Organization
Lat	Latitude
Lon	Longitude
MNS	Maritime Navigation System
MOB	Man Over Board
MRI	Modular Radar Interface
NIIC	Navigational Information Integration Centre
SOG	Speed Over Ground
TDC	Transportation Development Centre
TTBX	Time To Bow crossing
TTCPA	Time To Closest Point of Approach
TTG	Time To Go
USCG	United States Coast Guard
VRM	Variable Range Marker
XTD	Cross-Track Distance

1. INTRODUCTION

The St. Lawrence River is one of the most challenging rivers to navigate. It imposes many limitations on ship owners and exposes pilots to many risks. For example, cargo loading is restricted because of channel depth variations. Also, due to the removal of most navigational aids in wintertime, operations during that season are limited to daytime and good weather. As a result, speed and traffic reduction measures must be applied in order to maintain the safety of navigation on the St. Lawrence. The need therefore exists to create a better maritime navigation system that could answer the concerns of shipowners, pilots and public authorities. Such a system would allow increased ship cargo and nighttime winter navigation, enhancing the competitiveness of maritime transportation and ensuring the environmental safety of the river.

This report presents the research and development results of a project undertaken by Q-MAR Inc. for the development of an advance Maritime Navigation System (MNS) that integrates state-of-the-art technologies such as DGPS, RF modems and mobile computing, to provide a complete and integrated solution to the navigational challenges faced by mariners in constricted waterways. This project was conducted in close collaboration with the Transportation Development Centre (TDC) of Transport Canada, the Canadian Coast Guard, and the Canadian Hydrographic Service.

The MNS project was aimed at bringing several innovative aspects to the field of electronic navigation. Some of these are:

- concept based on an open architecture hardware design offering the plug-in compatibility of various hardware elements (e.g. the DGPS units) and the use of and respect for standard environments protocols (e.g. Windows)

- development of a portable configuration that would provide pilots with a tool for navigation on board foreign ships and other ships not equipped with a shipboard system

- integration and dynamic display of real-time water level information

- silent communication with surrounding MNS-equipped vessels for collision avoidance

1.1 Project Objective

The objective of the MNS project was to assist the master in enhancing vessel safety as well as contributing to economical vessel operation. Shipowners, Canadian Coast Guard, masters and pilots, port and Seaway authorities would all benefit from this objective which would translate into cost savings and improved vessel operation. The MNS implementation objective would be realized through:

- Maximized vessel loading. With more precise navigation, links to water level meters, and tide data, the system would allow a more accurate estimation of the channel depth, permitting increased shiploads.

- Extended accessibility. The MNS would greatly improve winter navigation in the St. Lawrence River. Since the lack of navigational aids in the river during winter months constrains vessels to daylight-only navigation, the MNS would provide a means to improve port activity and river trafic.

- Enhanced vessel safety. With more precise navigation, ship-to-ship and possibly ship-to-shore position reporting through RF modems, and computerized watch dogs alerting pilots of potentially hazardous situations, the risk of accident would be reduced.

- Reduced environmental disaster risk. A reduced accident risk would translate into a reduced risk of environmental disaster.

- A portable configuration would enable a wide diffusion and utilization of this technology, extending accessibility to the river, vessel safety and environmental safety.

1.2 Technical Objectives

Although this project covered the application of the MNS to navigation on the St. Lawrence River from the Montreal harbor, through Lake St. Pierre, to the Les Escoumins pilot station, the objective also included the design of technology that could be applied anywhere in the world where confined waterways represent a hazard to safe navigation. The technical and scientific objectives were:

- To provide high accuracy position information based on DGPS technology (using RTCM-104 v2.x sentences as provided by CCG owned transmitters). In case of GPS failure, MNS will resort to traditional navigation technology and computerized dead reckoning algorithms.

- To provide an information-rich navigation display showing channel charts, ship position, and much more.

- To establish a computer network through RF modem links between MNS-equipped ships, COWLIS, and shore stations (requires CCG to transmit the information).

- To develop two configurations of MNS: a shipboard configuration and a portable configuration.

- To develop routing algorithms using navigation data (charts, tide tables, currents, etc.) and real-time data (COWLIS, other ships, shipboard instruments, DGPS, etc.), which determine if sufficient under-keel depth exists to allow the passage of the vessel.

- To overlay the ship's radar on the navigation information display.

- To produce an open architecture system.

Many of these objectives presented technical and scientific challenges. They also depended on infrastructures (such as the DGPS) provided by other parties. We will see in the following chapters how challenges were met.

2. DEVELOPMENT METHODOLOGY

2.1 Overview

The design, development, and testing activities to be performed within the framework of the MNS project were divided into five distinctive phases. These are:

> Phase 1: Feasibility Study
> Phase 2: Pilot System Development
> Phase 3: Ship-based System Development
> Phase 4: User Trials
> Phase 5: Radar Interface Subsystem Development

Two of these phases (Phase 1 and Phase 5) contained GO/NO-GO decision points where authorization from the management and technical committees was required in order to proceed with the remainder of the project or phase. The following sub-paragraphs give an overview of the goal of each phase of the project.

2.1.1 Phase 1 - Feasibility study

The purpose of the feasibility study was to establish the user requirements, the technical feasibility, the economic feasibility and the detailed project plan for the development of the pilot and ship-based systems. This phase also included the development and evaluation of a prototype unit, which would help define the system specifications for both the pilot and ship-based systems. This prototype was to be a hybrid system between the pilot and ship-based configurations incorporating as much as possible generic features applicable to both versions.

A GO/NO-GO decision point was inserted at the completion of the feasibility study, allowing the Management committee to authorize or stop the remainder of the project.

2.1.2 Phases 2 and 3 - Pilot and ship-based system development

Phases 2 and 3 covered the development and evaluation of the pilot and ship-based system respectively, based on the system specification derived from the requirements in Phase 1. Within each of these phases, Beta prototypes were to be built and tested following pre-established operational test and evaluation procedures, prior to being subjected to on-board testing on merchant marine and Coast Guard vessels to verify the production readiness of the pilot and ship-based systems.

Phases 2 and 3 both ended with the delivery of a system to TDC.

2.1.3 Phase 4 - User trials

The user trials involved the production of additional Phase 1 type prototype systems to be tested over an extended period of time by two potential end users of the system. The main purpose of this activity was to acquire information about the reliability of the system software and hardware configuration in a ship environment. Other expected benefits of this activity included getting market attention and refining the user requirements.

Phase 4 was to be conducted concurrently with Phases 2 and 3, the pilot and ship-based systems development.

2.1.4 Phase 5 - Radar interface subsystem development

The purpose of Phase 5 was to develop radar interfacing capabilities to the system. The objective was to capture radar display feed to allow the representation of ARPA-like targets and the overlay of the radar image onto the screen. Phase 5 included a feasibility study to investigate the specific requirements of the radar interface. Prototypes would then be developed and evaluated in a laboratory environment. Integration of the radar interface to the Ship-based system was to be performed concurrent to Phase 3 operational and beta tests.

Similar to Phase 1, a GO/NO-GO decision point was inserted after the Phase 5 feasibility study. The development and integration of the radar interface were dependent on a GO decision from the Management committee.

2.2 Project Organization

A team of managerial and technical staff was set up by Q-MAR to perform the MNS project. The responsibilities for the various personnel categories are described below:

Project director: The project director provided technical guidance and project directives to the MNS team, and acted as a single point of contact for the Technical Committee. The project director also performed most of the required hardware integration.

Project administrator: Overall project administration and reporting, as well as the generation of deliverable documentation was the responsibility of the project administrator.

Product manager: The product manager had the responsibility of the software development for the whole MNS project. Carrying out the software implementation of design and development decisions made in concert with the project director was also the product manager's responsibility.

Technical staff: Development of algorithms, interfaces, and software coding was the responsibility of the senior technical staff.

During the three-year span of the project, the number of personnel varied according to workload and types of activities to the performed. However, the core team of managerial and technical staff dedicated to the Maritime Navigation System remained basically the same for the duration of the project. These key people are identified in Figure 2-1 below.

Project Director and administrator	**Technical Committee**
Patrice Piché	André Taschereau Gilles Ringuette Patrick Hally

Product Manager
David Jean

Technical Staff	**Consultants**
Philippe Quesnel Stéphane Gagnon	Institut Maritime du Québec Oceanex Centre Technologique en Aérospatiale
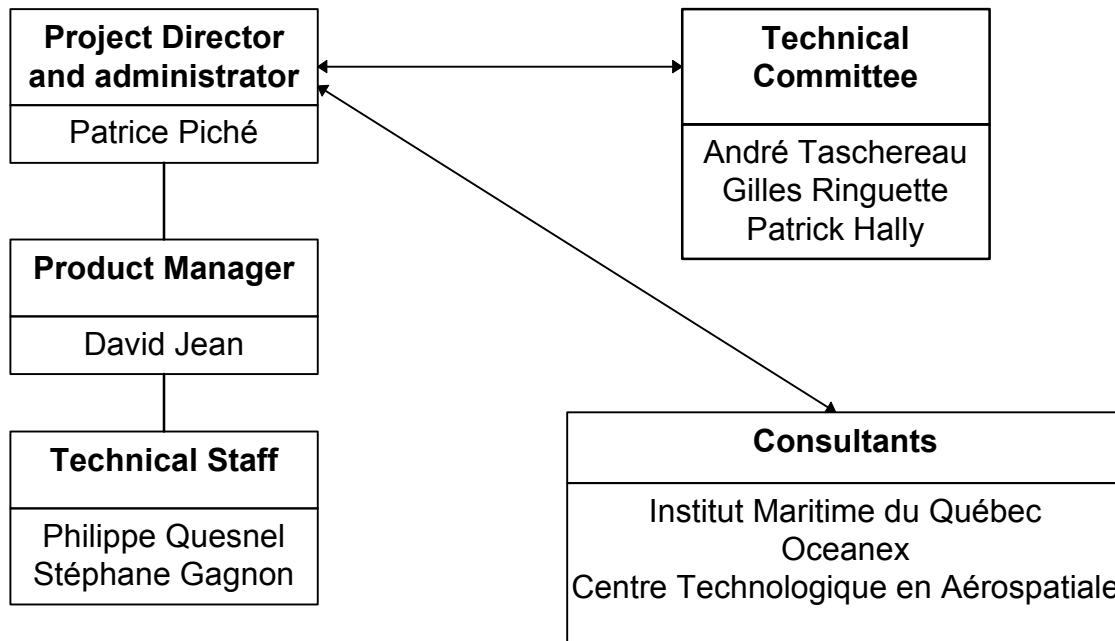
Figure 2-1 - MNS Project Organization

3. DEVELOPMENT CONSIDERATIONS

3.1 User's Requirements

User's requirements for a maritime navigation system were determined from a product comparison study, and from a task analysis report published by the Institut Maritime du Québec[1]. Each requirement of the exhaustive list compiled from the internal study and the IMQ report was analyzed and translated into corresponding system requirements. Each system requirement was in turn analyzed for its feasibility by being weighted against technical complexity, schedule, budget, and user interest considerations. This provided the basis for system specification determination.

It shall be noted that some of these requirements were fairly definitive, while others still had to be validated through testing and evaluation.

3.2 ECDIS Compliance

The single most important factor to be considered in the design and development of new electronic chart navigation system was ECDIS compliance. Although not fully ratified at the time, the ECDIS performance standard served as a guiding specification for many systems that were under development. Of course none of the systems on the market could claim ECDIS certification since certification methodology was not yet established by the International Maritime Organization/International Hydrographic Organization (IMO/IHO) committee (this was still the case at the writing of this report). Why then should we consider designing the MNS based on ECDIS requirements? Because ECDIS will eventually be the only legal alternative to paper charts, being therefore more than just a navigational aid.

For system development, ECDIS compliance signifies that an important percentage of the requirements would be specification-imposed rather than user's interest determined. This would have a certain impact on the features to be designed into the MNS. The decision for the MNS to meet the ECDIS requirements was made at time of technical feasibility analysis prior to the establishment of the system specifications. It was at this point also that the incorporation of other non-ECDIS related features presently not available on the market, such as portability and local area networking capability, that could become high priority items for certain classes of mariners, were evaluated.

3.3 Nautical Chart Format

Extensive efforts undertaken in the early days of the project revealed that supporting the NTX chart format was not a justifiable alternative. It was determined that problems encountered with unclosed contours (lines and areas) could not be overcome without manually correcting the chart data. Because of the importance of CHS data integrity, it was

---

[1] *Analyse des tâches et besoins*, Institut maritime du Québec, 1994

decided that efforts on the NTX format would be abandoned in favor of the upcoming DX90 (now S-57) international vector format.

The Canadian Hydrographic Service had already started chart conversion from the NTX format to the DX90 format, and indications were that CHS production schedule would be in line with foreseen MNS chart requirements.

The capability to support the widely used Admiralty raster charts would also be provided. It should be noted that the use of raster charts imposes some limits to the functional capabilities of the MNS.

3.4 Software and Hardware Development Environment

The development of the new generation of electronic navigation system was characterized by hardware flexibility and affordability. Hardware flexibility meant adaptability to user needs, for example, ship-based versus portable versions, It also meant ease of upgrade upon availability of higher performance hardware, and ease of maintenance. Only a Personal Computer (PC) platform with its open architecture could offer all of these advantages which are today considered mandatory to respond to the mariner's and shipowner's needs. Pentium™ 90MHz PCs offered the most advanced technology available at a reasonable price in early 1994, and were thus selected as the development hardware platform for the MNS project.

Software development was all performed in C high-level programming language, using the Microsoft Visual C^{++} and Watcom C/C^{++} development systems. The use of the two different compilers helped detect a greater amount of programming bugs in the early stages of development. In 1994, Windows NT™ was emerging as an operating system that offered full 32-bit support and advanced security features that were deemed important to an application like the MNS. It was therefore selected as the platform for software development.

3.5 System Specifications

A system specification identifying the functional requirements to be met for the design and development of the MNS, was prepared based on the results of Phase 1 feasibility study. Although this specification, included in Appendix A, was written to cover all possible requirements regardless of system configuration, it also contains a table identifying the applicability of requirements to specific configurations of the MNS.

3.6 Radar Interface

3.6.1 User requirements

The IMQ report

At Q-MAR's request, the Institut Maritime du Québec produced a comprehensive report[2] covering the user segment of the radar interface analysis. This report includes an overview of user's opinion, a thorough analysis of the mariner's tasks using the radar, a recommended development strategy, and a summary of the different types of radar presently available on the market.

As outlined in the report, the user requirements for a radar interface to the Electronic Chart Display and Information System (ECDIS) fall under two categories of tasks: collision avoidance and positioning. The context under which these tasks are performed, although relevant for operation in accordance with applicable navigation rules, was not subjected to distinction for the purpose of the development. All user requirements whether for performing collision avoidance or positioning tasks were be considered.

USCG evaluation

In January and February 1993, the United States Coast Guard conducted a performance evaluation of a near-ECDIS system to measure the contribution of ECDIS to the safety of navigation, the reduction in navigational workload, and the contribution of radar integration. The results of this evaluation were presented in an article titled 1993 At-Sea Evaluation of ECDIS written by I. M. Gonin and M. K. Dowd and published in the Winter 1994-1995 issue of NAVIGATION (Journal of the Institute of Navigation).

According to Gonin and Dowd, the contribution of the radar overlay to the ECDIS was measured to be "significant in improving navigational performance", helped reduce the navigation workload, and was ranked first as navigational performance factor. They also reported that it was the mariner's opinion that ECDIS with radar interface has "advantages over each of the systems separately". They indicated that maximum effectiveness would be achieved if all the functionality of both systems (ECDIS and radar) was combined into the integrated system.

Although these conclusions are general in nature, we nonetheless assumed that the incorporation of the radar interface to ECDIS (and the MNS) was desirable from a user's point of view, and would help reduce the navigational workload while contributing to safe navigation. The form of integration was to ensure that a maximum of radar functionality would be available on ECDIS.

---

[2] *Besoins des usagers, Interface radar*, Institut maritime du Québec, 1995

9

Field trials observations

During the conduct of field trials on the MNS, users were interrogated on an informal basis about the overlay of the radar image on the electronic chart. Findings were the same as reported in the IMQ report; some users would like it, while others see no reason to clutter the display with a radar scan. This reaction led us to believe that the quality of the radar overlay seen so far by users may be the single most important factor explaining its semi-unpopularity. Maybe some users don't like the radar overlay because they had not seen a very good one yet. This viewpoint was used as a guide for the development and integration of the radar interface.

Operation of the radar under normal sailing conditions was also observed. It was noted that the functions mostly, and almost exclusively, used were the Electronic Bearing Line (EBL), the Variable Range Marker (VRM), and the Range Ring. The interest from the pilot community to have these tools available on the MNS explains why these were added.

Summary list

The various user requirements for the radar interface can be extracted from the information compiled as reported in the above paragraphs. These are categorized under either one of the two main radar interface purpose identified in the IMQ report and paragraph 1, or under the "general" category.

Table 3-1 - User Requirements List

Category	Requirements
Collision avoidance	Closest Point of Approach (CPA) of target
	Time of closest point of approach of target
	Course of target
	Speed of target
	Position of target
Positioning	Beam Bearing
	Electronic Bearing Line (EBL)
	Variable Range Marker (VRM)
	Range Ring
General	Overlay radar image to electronic chart as an option
	Availability of ECDIS and radar tools

3.6.2 System requirements

ECDIS requirements

Since the Maritime Navigation System (MNS) was being developed in accordance with the requirements of the performance standards for ECDIS established by the International Maritime and Hydrographic Organizations (IMO/IHO), the integration of the radar interface to

the MNS was also to be in accordance with those requirements. The following paragraphs identify the requirements.

Maritime Safety Committee Circ. 637 para. 6.3

- Radar information may contain both the radar image and ARPA information.

- The radar overlay should match the scale and orientation of the electronic chart.

- The radar image and the position from the position sensor should both be adjusted automatically for antenna offset from the conning position.

- Displayed ship's position should be manually adjustable to match the radar image to the electronic chart.

- It should be possible to remove the radar information by single operator action.

IHO Special Publication No. 52 Appendix 2 Annex A para. 4.2.3

- The radar image overlay can be generated using two different intensities of the radar color: RADHI for high intensity echoes, or RADLO for low intensity echoes.

- If only one intensity is used, RADHI should be used.

- If other intensities are to be used, they should be interpolated between RADHI and RADLO.

- A separate color token (ARPAT) is used for ARPA targets and infos tagged on them.

3.6.3 System specifications

The system specifications identifying the functional requirements that were to be met by the design of the Maritime Navigation System radar interface are included as Appendix B.

4. PROOF OF CONCEPT

The prototype version of the Maritime Navigation System was developed as a proof of concept model to verify the functionality of basic elements of the system specification. The prototype therefore only met a subset of the requirements identified for the generic MNS. However, the elements designed into the prototype were sufficient to verify the capability to display a local chart, show accurate vessel position and movement on that chart, and properly respond to user commands.

4.1 Functional Design

The functional elements designed into the prototype system are presented in block diagram form in Figure 4-1. Each element can be traced back to user requirements, and represent either a system input or output that was supported by the prototype system.
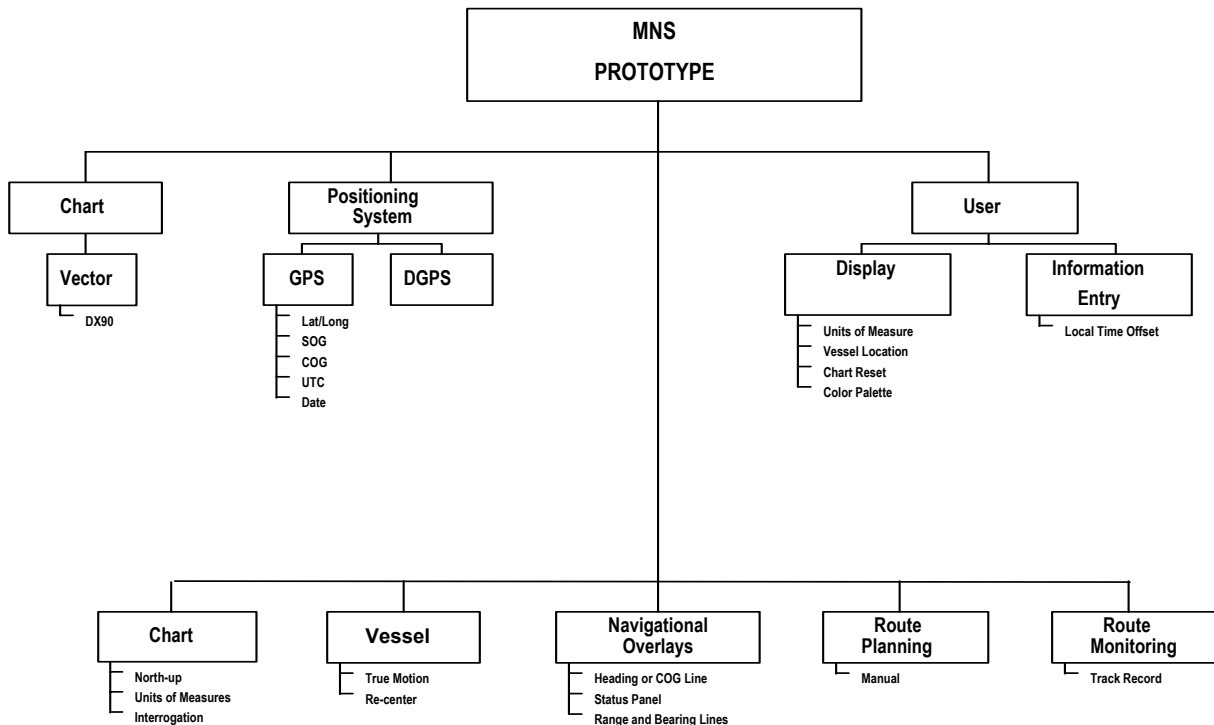
Figure 4-1 - MNS Prototype Functional Design Elements

4.2 System Software Architecture

An architecture consisting of five modules was designed to provide an adequate software structure, and the necessary growth potential to easily incorporate additional functions. It was important at that point to consider future elements to be included in either the pilot or ship-based configurations of the MNS in the establishment of the software architecture, to simplify overall program design by reducing the routine interaction, and increase program maintainability, thus facilitating the adaptation of software elements unique to the various configurations.

The five modules are: the User Interface (UI) module, the Navigation module, the GPS (positioning) module, the Cartographic module, and the Alarm module.

The relationship between modules is depicted in Figure 4-2, and a description of each module and of the message passing scheme is given in the following paragraphs.
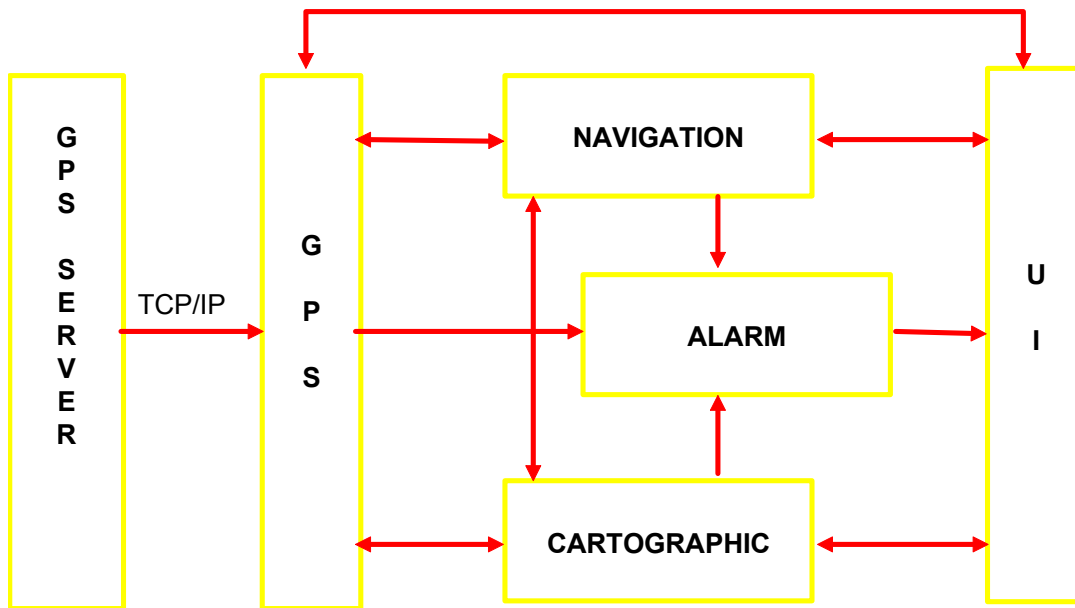
Figure 4-2 - MNS Software Modules

4.2.1 User interface module

The User Interface module provides the interface between the user and the system. It reads commands entered by the user and routes them to the appropriate module for processing. All user entered requests are routed through either the Main UI sub-module, or the Chart UI sub-module.

The Main UI sub-module handles all general purpose commands such as units of measure selection. Other commands or operator actions directly related to displayed charts (scrolling, panning, zooming...) are handled by the Chart UI sub-module.

Design of the UI module was to take advantage of the Windows^{TM} operating environment with pull-down menus, dialog boxes and windows management. The screen was divided as follows: top section for pull-down menus and toolbar buttons, right-hand section for the Status Panel, and remainder for chart display.

4.2.2 Navigation module

The Navigation module performs all route monitoring related calculations such as cross-track error, monitors sailing areas where special conditions exist, and verifies the depth in the ship's safety area.

A minimum of route planning and monitoring was available for the MNS prototype. A primitive method of entering waypoints was designed to allow route planning capability. This method was simply clicking to enter straight route segments between waypoints.

Route monitoring capability consisted of verification of vessel's track against the planned route, verification of entering and leaving wheel over points (circular region centered on current waypoint), and automatic selection of next waypoint. Information on cross-track error, current waypoint and next waypoint (lat/long, range/bearing, ETA/TTG) was reported in the status panel section of the display.

4.2.3 GPS module

The primary task of the GPS module is to provide positioning data to other modules. Position, course over ground, speed over ground, and time data transmitted by the GPS receiver is decoded by the GPS server which in turns sends the information to the GPS module. Dead reckoning navigation is also performed by the GPS module when positioning data not be available from the GPS server.

4.2.4 Cartographic module

The Cartographic module handles chart loading, manipulation, and display tasks. There are two subsets in this module: Chart Control, and Chart Window. The Chart Control handles all general requests or commands applicable to all charts regardless of their respective display status. It is the Chart Window sub-module that manipulates displayed charts as necessary or in accordance with received requests. Chart interrogation queries, whether from user or navigation module, are also performed by this module.

4.2.5 Alarm module

The Alarm module manages all alarms and alerts received from the Navigation, Cartographic, and GPS modules, and routes them to the UI module. It will also be responsible to generate audible alarms.

The visual alarms supported by the MNS prototype were: chart overscale, critical point entering and leaving (wheel over point), insufficient depth, cross-track error, and GPS failure. All alarm messages are displayed in an movable, re-sizeable Alarm window. Simultaneously, the background color of the toolbar is changed to yellow or red depending on the severity of the alarm condition encountered. The possibility to acknowledge the alarm condition is provided.

4.2.6 Message passing

The program being constructed around five "independent" modules, communication between those modules is of primary importance. It is through the communication channel that each module obtains data necessary to perform its tasks and send its outputs to the appropriate module for either further processing or display update.

The inter-module message passing scheme for the MNS is built around the basic principle that, except for chart updates, the communication shall be synchronous and non-queued.

Each module has a public structure that can be directly accessed by all modules for simple queries. More complicated queries need to send a message to the target module, which then executes the processing and returns the result in a buffer allocated by the caller. Each module also has a private structure, not accessible by other modules, for intra-module processing and result keeping.

By providing a formal message map, the overall program is simplified, made more modular and maintainable.

4.3 Hardware Design

The block diagram depicting the layout for the hardware element of the prototype system is shown in Figure 4-3. These hardware elements provided the necessary platform to accept all system inputs, and display all system outputs to the user.

Figure 4-3 shows that the prototype system consisted of two major assemblies; a computer assembly, and an antenna assembly. The computer assembly included a central processing unit, a 1 280 x 1 024 color display, 540 MB of hard disk, a keyboard and pointing device. The antenna assembly included a DGPS beacon receiver and antenna, and a GPS receiver and antenna. The two assemblies communicate through a hardwired RS-232C interface.

All hardware elements of the two assemblies were available off-the-shelf. The detailed design will specify more precisely the minimum requirements to be considered for procurement.
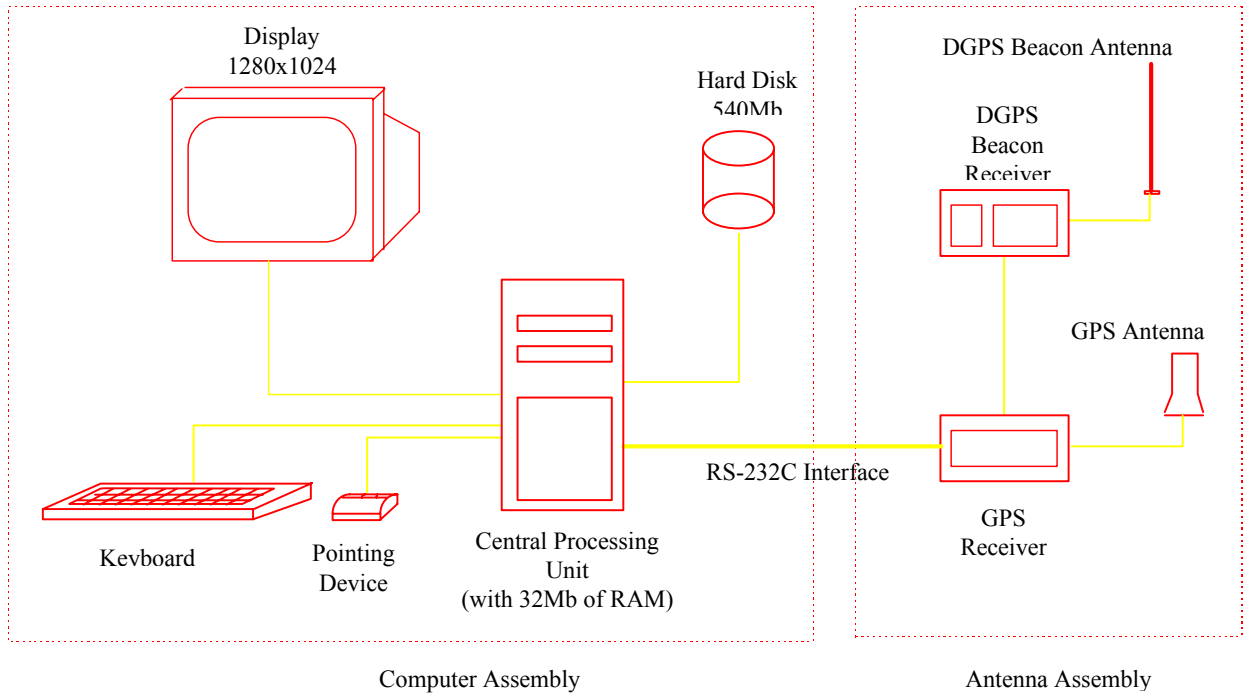
Figure 4-3 - MNS Prototype Hardware Assemblies

4.4 Test Plan and Procedures

Testing of the MNS prototype was divided into two categories: development tests, and operational tests.

4.4.1 Development tests

The development test was designed to verify, to the greatest possible extent, the functionality of capabilities designed into the prototype unit. This made prototype testing equivalent to system software testing with commercial off-the-shelf hardware providing support as test equipment.

The functions, features, and capabilities of the prototype MNS were categorized in terms of positioning system dependence. Several functions, such as chart manipulation, did not need the positioning of a vessel on the chart for testing. These "Stand Alone" tests only required an appropriate S-57 format chart. System response was measured against user inputs and requests. The following chart manipulation functions and informations were tested this way:

- north-up orientation
- zooming
- panning
- scrolling
- interrogation
- multiple windows
- color palette
- overscale indication
- manual route planning
- cursor lat/long coordinates
- local time offset (time zone selection)

Other functions however, did require the positioning of a vessel on the chart to exercise and test them (e.g. Course Over Ground Line). The most advantageous way to test those functions in a controlled fashion was to simulate positioning system inputs and therefore generate vessel movement scenarios. To support such simulation capabilities, a very basic GPS position data generator was developed and interfaced to the GPS Server module.

These "Simulation" test were performed using a user entered scenario with a constant vessel speed, and allowed for the verification of the following functions:

- true motion mode
- course over ground line (projected)
- ship recenter region setting
- ship recenter position setting
- ship recenter (chart reset)
- range and bearing line (relative to ship)
- vessel past track
- units of measure selection

4.4.2 Operational tests

The philosophy of the prototype system operational test differed slightly from that of the development test. The actual positioning system (GPS/DGPS) was now integrated into the MNS prototype, and verification of proper geographical positioning of the vessel relative to the chart became the most significant goal of this test.

To verify proper vessel positioning by the prototype system, an S-57 format chart containing known geodetic points was created. With the prototype system located at a designated geodetic point, system calculated latitude and longitude (shown as ship position on the status panel) could then be compared to surveyed latitude and longitude. Displacing the prototype system from one geodetic point to another allowed the verification of consistency

between latitude/longitude readings. This portion of the test was referred to as the "static" test.

To further emphasize the correctness of the MNS displayed information, the inherent precision limitations of the positioning system had to be eliminated from the equation. This was achieved by reading through a remote interface computer the information transmitted by the GPS. Comparing the GPS output data to that computed and displayed by the MNS provided an indication of the degree of data degradation, if any, and of the exactitude of MNS performed manipulations and computations. This verification perfectly complemented the validation of correct geographical representation done through comparison with geodetic points.

An approximation of proper indication of Speed Over Ground (SOG) and Course Over Ground (COG) was obtained by displacing the prototype system with a mobile platform equipped with a speed indicator and compass or other heading indicator. SOG and COG data displayed on the system status panel would then correspond, within a certain limit, to mobile platform indicators, and the COG line would vary in length and orientation in accordance with speed and heading variation of the mobile platform. The "dynamic" response of the MNS prototype would then be verified.

4.5 Test Results, Analysis, and Recommendations

4.5.1 Development tests analysis

The stand alone test was performed in a straightforward fashion without any problem. However, it was noted that none of the CHS charts contained text. Certain test step verifying this item therefore had to be performed with a foreign (Australian) S-57 chart.

The stand alone test successfully demonstrated that chart manipulation features were fully functional.

The simulation test was also conducted without major problems. Only one potentially abnormal condition was encountered during the test when the label of the **Center ship** was not readily displayed when the cursor was positioned on the relevant toolbar button. This item was subjected to further investigation.

The simulation test successfully demonstrated that advance chart manipulation, route planning, and route monitoring features were fully functional.

4.5.2 Operational tests analysis

The static test had to be performed without the additional accuracy normally available from DGPS correction signals. What seems to be a communication problem was experienced with Magnavox MX 51R Beacon receiver, with the result that it could neither be initialized from the PC Controller, nor transmit proper correction data. Measurements were nonetheless made, but those are of GPS precision only.

Static measurements made at a geodetic point surveyed by the city of Longueuil engineering and public works services, revealed that the difference between the ship position reported by the MNS and the actual surveyed point was calculated to be 56.04 m, which is within the precision guaranteed by the GPS system. This validated the data supplied by the GPS receiver. The first point was therefore confirmed; the MNS did not distort positioning data transmitted by the GPS receiver.

Next, the accuracy of the ship's geographical representation was measured by placing the cursor on the geodetic point with the greatest accuracy possible and reading the range data indicated by the MNS prototype. The range thus measured between the geodetic point and the ship was 55.69 m, for an error of 0.35m (if we compare to the 56.04m error measured previously). This therefore confirmed that ship's geographical position representation by the MNS was correct.

Verification of cursor's positioning on the display was also successfully performed by comparing a cursor position with a geodetic point which geographic coordinates were precisely known. The results showed that the cursor geographical representation on the chart was within one metre of that of the surveyed geodetic point.

The accuracy of range and bearing data calculated by the MNS was verified concurrently. Figure 4-4 depicts how the measurement was made (90KM102 and 90KM103 are two geodetic points). An error of 71.50 m was calculated between the geodetic point and the "ship", which is within the precision expected from the Global Positioning System. Note that this value includes all possible errors from the GPS and the operator. The results therefore positively demonstrated that information provided by the MNS was within expected accuracy.
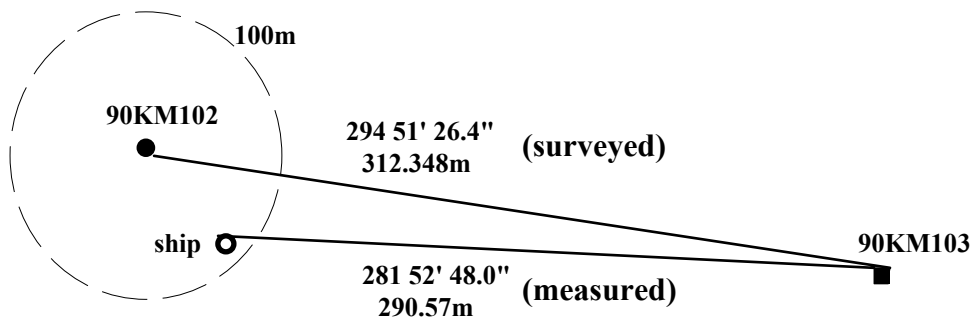
Figure 4-4 - Measuring the Accuracy of Bearing and Range Data

The dynamic test took place on board M3i System's boat. For this test, the Magnavox MX 50R Beacon receiver was used and was successfully tuned to receive correction signals from the St. Jean station. The dynamic test was a mixture of pre-determined measurement requirements and of free operation of the system.

The first verification that was made as part of the dynamic test was the dynamic representation of ship's movement on the chart against visual observation of true ship movement. It was evident, when taking land masses as reference point while entering or leaving the Longueuil marina or approaching docks, that the MNS displayed the ship on the chart with a correct look and feel.

The verification of MNS reported speed over ground was performed in two passes to eliminate the water current factor which affected the ship's speed through the water indicator. On the up-river pass, the MNS reported a SOG of 2 kn lower than the ship's STW, whereas it was the opposite on the down-river pass. This indicated that the MNS reported SOG had to be correct. This was furthermore confirmed by the relevant hydrographic chart (no. 1310) which indicates a current of 2 to 2.5 kn in the area of interest.

Unfortunately, the course over ground could not be verified due to the untrustworthiness of the on-board compass. This item was however unofficially tested internally by running in simulation mode the file recorded during the test and comparing MNS reported COG to bearings measured from hydrographic chart 1310. Observations confirmed that MNS' COG was correct.

Verification of correct COG line length was accomplished while the recorded voyage file was played back in simulation mode. Measurements confirmed that the length did correspond to 6 minutes of voyage (or was equal to 10 times the SOG).

4.5.3 Recommendations

The successfulness of both the development and operational tests minimized the number of significant functional changes considered necessary prior to proceed with user trials (Phase 4 of the project).

During some of the tests, few minor software defects (bugs) were noticed. In fact, some already had been identified before the test in a *Bug List* dated 27 Sep 94. Fixing these identified bugs remained a priority.

Potential problem areas identified during the test, namely the toolbar labels and the MX 51R beacon receiver integration, were also investigated and resolved.

It was also imperative that testing of the MNS did not stop with the completion of the development and operational tests. System testing continued on a daily basis for new bugs search and thorough testing of bug fixes and changes before implementation.

Efforts to measure system's user friendliness were started and resulted in some pertinent feedback. Because the suggestions compiled at that time were from a very small sample of the marine community, each had to be evaluated carefully before implementation.

In conclusion, the development and operational tests proved that the functionality built into the current prototype MNS version met the identified prototype requirements, and provided a solid base for future development of additional capabilities and features. Recommendations were to:

- Fix defects identified in *Bug List* dated 27/09/94
- Investigate and resolve the toolbar label and MX 51R integration problems
- Continue daily system testing
- If possible, incorporate minor modifications to the user interface to facilitate system's operation

5. USER TRIALS

5.1 Alpha Installations

The field trials of the prototype version of the MNS were performed with two installations on board vessels sailing the St. Lawrence River on a regular basis. This arrangement provided for maximum utilization of the system and exposure to potential users. The two installations, designated as Prototype 1 and Prototype 2, are described below:

Prototype 1
Configuration: - pentium 90Mhz, 40 MB RAM, 1GB hard disk
                 - trackball
                 - MX 4200D GPS receiver (with antenna)
                 - MX 50R Beacon receiver (with antenna)
                 - Uninterruptible Power Supply
Software: - Windows NT 3.5
                 - MNS version 1.1 built 10
                 - Server version 1.0
Installation date: 19 December 1994
Vessel name/owner: CABOT / OCEANEX
Vessel type: Container
Sailing route: Montreal - St-John's (NFLD) weekly

Prototype 2
Configuration: - pentium 90Mhz, 40 MB RAM, 1GB hard disk
                 - mouse
                 - MX 4200D GPS receiver (with antenna)
                 - MX 51R Beacon receiver (with antenna)
                 - Uninterruptible Power Supply
Software: - Windows NT 3.5
                 - MNS version 1.2 built 5 and 6 (see note 1)
                 - DX90 Viewer version 1.2 built 5 and 6 (see note 1)
                 - Server version 1.1
Installation date: 30 March 1995
Vessel name/owner: Martha L. Black / Canadian Coast Guard
Vessel type: Buoy tender
Sailing route: Quebec City - Montreal

Note 1: Two versions of the MNS application software were installed in Prototype 2. The extra version featured, for the first time, the seamless world viewer for S-57 format charts. The unforeseeable response of users to this new method of handling non-celled charts prompted Q-MAR to also install a conventional chart handling version.

After installation of the prototype, a short but detailed explanation of systems operation and features was given to the ship's captain and his crew. On both installations, part of the MNS maiden voyage was sailed with Q-MAR representatives to ensure proper system operation

and to provide on-site support as required. Other voyages were also made at regular intervals for data collection.

Subsequent semi-permanent or temporary installations were also performed on board the Oceanex vessel Cicero, and the CCG vessels Pierre-Radisson and F.C.G. Smith, where additional comments were collected.

All interventions made and comments/suggestions formulated by users were recorded. See Appendix C for a log of interventions and comments.

5.2 Post-trials Recommendations

5.2.1 Interventions

Several interesting facts were extracted from the interventions analysis. First, out of a total of twenty-three (23) problem-related interventions, only one (1) was attributed to hardware. Commercial off-the-self hardware utilized for the prototype, although not suited for marine environment, proved to be surprisingly reliable. The overall performance of the DGPS beacon receiver was of some concerns. However, although no hard failure was experienced, it was observed, with the Canadian Coast Guard expert, that the signal to noise ratio was about half of what it should be under normal operating conditions (tests conducted by the CCG in their laboratories confirmed this). Further investigation with the manufacturer on equipment performance was recommended before selecting the MX 51R from Leica as the beacon receiver of choice for the Maritime Navigation System.

All of the other problem-related interventions were attributed to software. Of these, twelve (12) were successfully solved within a subsequent version or built of either the application or the viewer, three (3) did not re-occurr and were believed to have been solved with other corrections implemented, two (2) were expected to be eliminated through redesign of the server module, and six (6) needed to have solutions developed and incorporated.

Recommendations for the outstanding software problems were as follows:
- Look for any re-occurrence of problems related to opening of world map window, application freeze and loss of current waypoint.

- Develop solutions for the problems with automatic recentering, tools activation, and past track.

- Limit the amount of allowable zoom in as a function of the chart compilation scale.

- Ensure that problems related with the GPS server are eliminated with the redesign of the server.

In addition to all this, it was recommended to continue field trials as an ongoing activity. From the data collected during the trials, our conclusion was that the two current installations, and other potential ones, provided unique platforms for identifying problems in a real-life operating environment, and verifying the successfulness of the corrections implemented.

5.2.2 Comments

The incorporation status of the various comments made during the trials by users is summarized in Table 5-1:

Table 5-1 - Comment Status Summary

Category	Incorporated	Under Investigation	Not planned for Incorporation	Total
User Interface	11	19	2	32
Chart Presentation	5	4	7	16
Route Planning	2	4	-	6
Route Monitoring	6	13	2	21
General	2	1	-	3
Total	26	41	11	78

Of the comments that were attributed a "Not planned for incorporation" status, seven (7) were considered to be in conflict with the ECDIS standard and its presentation library, and two (2) were related to preliminary status of the CHS S-57 charts.

A great majority of comments addressed the user interface and route monitoring aspects of the system. This provided a clear identification of the areas requiring some adjustment.

The present user interface was found to be insufficiently intuitive for operation by users with limited knowledge or experience with today's windows oriented look and feel applications. Redesign of the user interface to a less "computerized" look was recommended. This redesign would take into account noted user comments such as automation of functions, use of function keys, etc. The suggestions made by users were important in considering the user interface for the pilot system configuration which has considerably less screen "real estate" than the ship-based configuration.

Development of the route monitoring mode was also to be continued. Making additional information available such as vessel's heading and positioning system status was considered very important for proper interpretation of the information graphically displayed.

The design and implementation of a chart editor had been started subsequent to comments raised in the chart presentation category. This editor would be extended to include route planning items (such as waypoints) to satisfy some of the comments made regarding route

planning. The capability to handle the Canadian Hydrographic Service S-57 chart in a seamless fashion also had a favorable effect in facilitating chart loading and manipulation. The next recommended step was to investigate the possibility of incorporating automatic loading of the next chart to be sailed.

With the trials on Prototype 2, it became evident that one system cannot satisfy all users. Coast Guard vessels do not perform the same tasks as merchant ships. We can assume this is also the case for other types of vessels. Trying to design one system that would "do it all" is not believed to be the proper approach as it would result in an unnecessarily large application with superfluous functions for a lot of users. It is recommended to develop several "special packages" containing the basic navigation module but supplemented by a set of specific tools designed for specific tasks such as buoy tending (as done by the Martha L. Black).

It was recommended that all the comments and suggestions still "under investigation" be investigated and if possible incorporated for further testing and comments.

Design of the user interface and of various functions is really an iterative process. Comments are raised, corrections are made, and a new version is subjected to comments again. Continuing field trials are considered essential to the development of an MNS for the users.

Figure 5-1 - Installation on board the F.C.G. Smith

Figure 5-2 - Installation on board the Cabot
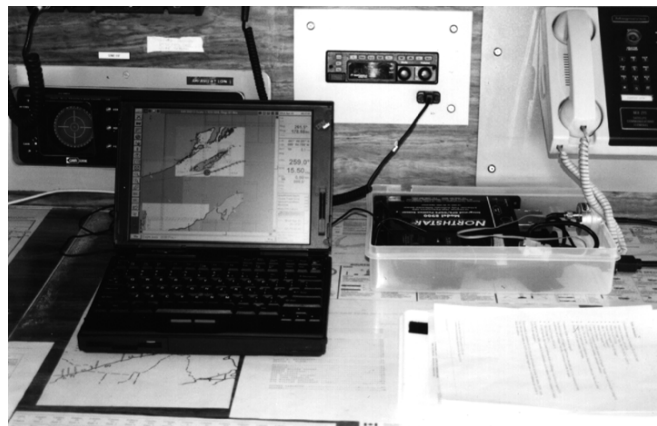
Figure 5-3 - Pilot system on the CCG Vessel Pierre Radisson

6. SOFTWARE EVOLUTION

6.1 Functional Growth

Based on the results of the MNS prototype testing in laboratory and real-life environment, and on the recommendations formulated following Phase 1 and Phase 4 activities, software development was continued in line with the established specifications. Figure 6-1 identifies the elements that were to be incorporated into the ship-based and pilot systems, and the following paragraphs describe how the additional functions were to operate.

6.1.1 Charts

Raster charts
The loading and viewing of charts in raster format was to be done in a fashion similar to that of vector chart format. This meant that in the World window, an outline of available raster charts was to indicate the coverage extent. Double-clicking within a raster chart outline would result in the loading of this chart into a chart window.

Of course, raster charts do not contain the same level of information as vector charts, so some system functionalities would be limited when working with raster charts. Some of these functions include chart interrogation, route planning, depth alarm, etc.

Seamless world
Vector and raster charts would be displayed in a seamless fashion with the possibility to display several charts within the same chart window.

Chart editor
A vector chart editor was to be created to add, delete, or move chart objects. Chart editing would be done in accordance with the rules of IMO/IHO S-52 publication; objects added manually by the operator are to be orange colored, deletion of operator added objects would result in the erasing of the object, deletion of chart objects would be shown with a slash. Under no circumstances would it be possible for the operator to "erase" original chart data from the chart file.
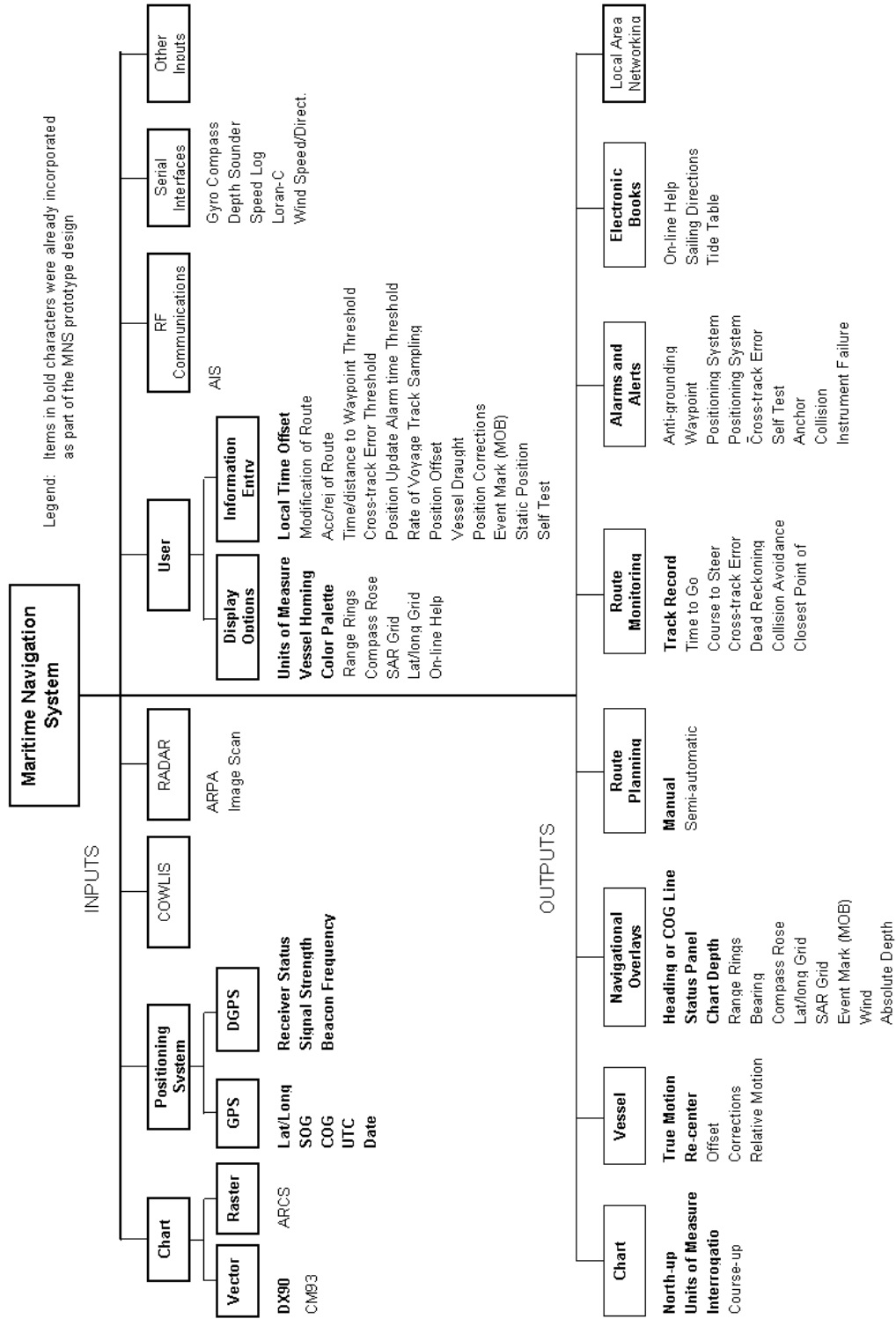
Figure 6-1 - MNS Functional Design Elements

Maritime Navigation System

Legend: Items in bold characters were already incorporated as part of the MNS prototype design

INPUTS

- **Chart**
  - Vector
  - Raster
  - **DX90**
  - CM93
  - ARCS
- **Positioning System**
  - GPS
  - DGPS
  - **Lat/Long**
  - **SOG**
  - **COG**
  - **UTC**
  - **Date**
  - **Receiver Status**
  - **Signal Strength**
  - **Beacon Frequency**
- COWLIS
- RADAR
  - ARPA
  - Image Scan
- **User**
  - **Display Options**
    - Units of Measure
    - Vessel Homing
    - **Color Palette**
    - Range Rings
    - Compass Rose
    - SAR Grid
    - Lat/long Grid
    - On-line Help
  - **Information Entry**
    - **Local Time Offset**
    - Modification of Route
    - Acc/rej of Route
    - Time/distance to Waypoint Threshold
    - Cross-track Error Threshold
    - Position Update Alarm time Threshold
    - Rate of Voyage Track Sampling
    - Position Offset
    - Vessel Draught
    - Position Corrections
    - Event Mark (MOB)
    - Static Position
    - Self Test
- RF Communications
  - AIS
- Serial Interfaces
  - Gyro Compass
  - Depth Sounder
  - Speed Log
  - Loran-C
  - Wind Speed/Direct.
- Other Inputs

OUTPUTS

- **Chart**
  - **North-up**
  - **Units of Measure**
  - **Interrogatio**
  - Course-up
- **Vessel**
  - **True Motion**
  - **Re-center**
  - Offset
  - Corrections
  - Relative Motion
- **Navigational Overlays**
  - **Heading or COG Line**
  - **Status Panel**
  - **Chart Depth**
  - Range Rings
  - Bearing
  - Compass Rose
  - Lat/long Grid
  - SAR Grid
  - Event Mark (MOB)
  - Wind
  - Absolute Depth
- **Route Planning**
  - **Manual**
  - Semi-automatic
- **Route Monitoring**
  - **Track Record**
  - Time to Go
  - Course to Steer
  - Cross-track Error
  - Dead Reckoning
  - Collision Avoidance
  - Closest Point of
- **Alarms and Alerts**
  - Anti-grounding
  - Waypoint
  - Positioning System
  - Positioning System
  - Cross-track Error
  - Self Test
  - Anchor
  - Collision
  - Instrument Failure
- **Electronic Books**
  - On-line Help
  - Sailing Directions
  - Tide Table
- Local Area Networking

6.1.2 Route planning

Semi-automatic route planning
Manual and semi-automatic route planning were to be integrated into a single route planning mode (and window). By default, and for safety reasons, the route planning mode would be semi-automatic, with the system scanning the electronic chart for obstructions to safe navigation as waypoints were being positioned along the route. Ship`s parameters (length, width, draught) were to be considered by the system to determine unsafe conditions. If the planned waypoint and/or leg line crosses an unsafe area, the operator would be warned and the entry refused unless overruled by the operator (manual route planning).

It would also be possible for the operator to enter various waypoint and leg line attributes as the route is being planned. As a minimum, available attributes would include:

waypoint: - cross-track radius
              - waypoint name
              - wheel over point
              - waypoint arrival alert
              - user`s remark

leg line: - cross-track distance threshold
              - planned speed

Route editing
The route editing function was to allow modification of the route where waypoints and leg lines could be moved, deleted, or assigned new attribute values. Modifications would be done while viewing the original route file, and results would be saved either as a replacement to the original route, or as a new route.

6.1.3 Route monitoring

Dead reckoning
The dead reckoning function would be activated automatically upon failure of the main positioning system. When a positioning system failure was triggered, a window would pop up to allow the operator to enter a ship's speed and course over ground and/or heading. The system was to use this information to track and display ship's progress on the electronic chart.

It would also be possible for the operator to position the ship at a discrete latitude and longitude position, from which operator entered information was to be applied.

Route data
Information on the progress of the ship relative to the planned route waypoints would be removed from the status panel (where it was located in the MNS prototype version), and re-located into a unique window. This window would provide information on all waypoints of the route instead of the next two like originally provided on the MNS prototype. Waypoint name, latitude/longitude, Estimated Time of Arrival, Time To Go, Course To Steer... were the type of information to be provided for each waypoint.

ARPA targets
ARPA targets acquired from either the AIS system or from the radar ARPA module interface would be displayed on the chart with the proper symbology. It would be possible to click on the ARPA target to obtain information about the target course and speed. There would be a way (such as assigning a number) to link each target to its own information window.

Closest point of approach
The closest point of approach information would be calculated for each target and displayed in the target information window. The following information would be provided:
- distance to target at CPA
- target bearing at CPA
- ETA at CPA
- TTG to CPA

6.1.4 Navigational overlays

Compass rose
The compass rose symbol had been removed from the S-52 presentation library. It was replaced by a "North" indicator to be part of the chart base display layer. This indicator would therefore always be displayed and could not be removed from the chart.

Range rings
To take advantage of the flexibility offered by software, it was preferable to have a single range ring of adjustable radius. A menu command would be provided to activate and de-activate the range ring tool. The radius of the range ring would be adjustable using designated keyboard keys, and the value of the radius would be indicated in the status panel in the selected units of measure for distances.

To provide additional information, 5° markings could be added on the periphery of the range ring.

Electronic bearing line
The Electronic Bearing Line (EBL) was to be displayed as a rubber band between own ship, or any other point, and the cursor. By default, the EBL origin would be own ship. The length and bearing of the line would be indicated in the cursor section of the status panel.

Beam bearing
The beam bearing tool was to display a perpendicular to the ship's centerline. It would be possible to vary the length of the beam bearing. The length of the beam bearing, from the ship to one extremity, was to be indicated in the ship section of the status panel.

Variable range marker
The Variable Range Marker (VRM) was to be displayed as a circle of variable radius centered on the ship or any other designated point. The radius of the VRM would be equal to the ship, or point of origin, to the cursor.

Cursor VRM
The cursor VRM was to be displayed as a circle centered on the cursor. It would be possible to change the radius of the circle. The cursor VRM would remained attached to the cursor as long as it is turned on.

Cursor window
A cursor window would provide information on the movements of the ship relative to the cursor. Information to be provided would include: Estimate Time of Arrival and Time To Go.

Wind speed and direction
Information obtained from the anemometer and wind direction indicators would be calculated back to true components (versus relative), and be displayed preferably in a graphical manner as an attachment to the range ring tool for example.

Absolute depth
Water level above chart datum entered by the user or acquired from COWLIS, was to be applied as a vertical offset to chart depth data. When such an offset was applied, an indication would be given in the status panel along with its current value.

6.1.5 Electronic books

Electronic books would be accessible from the Help menu. The on-line help system would contain the information on the application and how to operate it. The sailing directions and tide tables would also be accessible from the same menu. The electronic text files for these two books were to be made available from the publisher or other authorized agency for usage on the MNS.

6.1.6 Self test

Self testing of the ship-based system would take advantage of the self test capabilities of the various components of the system, examining it on a component by component basis:

Computer hardware: tested at power up as the computer cycles through a memory check and detection of present hardware components

Operating system: tested at power up by verifying the presence of a working operating system and its components

MNS application: testing of the presence of the various files and components when application is started

Once all the above components were running, most hardware, operating system, and application problems would be automatically detected by the system.

6.1.7 Alarms

In a general manner, it would be possible to set the signature of individual alarms to help differentiate them by audible means. The number of "beeps" to be generated when the alarm was originally triggered, the reminder repeat rate, and the acknowledge condition to stop the audible alarm, were variables that the operator would be able to set for the various types of alarms

Positioning system alarm
The positioning system alarm was to inform the operator of the failure of the GPS/DGPS positioning system. The following conditions would constitute a failure of the positioning system:

- a GPS server is not opened and communicating with the client module
- loss of the TCP/IP link between the server and the client module
- no GPS data received by the server
- "invalid fix" message received from the GPS
- no DGPS data received by the server

When one of the above conditions was encountered, the MNS would trigger the proper alarm (GPS and/or Beacon) of the status panel.

Critical positioning information such as HDOP, mode of navigation, number of tracking satellites, beacon frequency, etc. would be displayed at all times in the status panel.

Instrument failure alarm
The instrument failure alarm was to be activated whenever a peripheral equipment on a serial communication link sent a no-go status message, or when a communication problem was detected between the peripheral server and the associated client.

This would result in an alarm condition being reported in the status panel, and an appropriate identification of the failed peripheral in the message window.

Anchor alarm
The anchor alarm was to be activated if the vessel drifts beyond a certain limit while under an anchorage condition. To implement this alarm, it would be possible for the user to specify to the system the anchorage condition, and set a certain distance threshold value that will trigger the alarm if exceeded.

Self test alarm
The self test alarm was to inform the operator that the system had failed its power up test, or that a problem had been detected while the system was running. The way by which the operator was informed of the failure was to be dependent on which component failed and when.

Failure of the hardware or the operating system at power up was to be reflected by messages or problems in booting the computer or starting the operating system.

Failure of the MNS application either at start-up or under running conditions would be indicated by message boxes popping-up to indicate the nature of the failure.

6.1.8 User interface

The appearance of the MNS display was to reflect the changes recommended by users during the field trials of the MNS prototype.

Even with a relatively large screen size, judicious usage of the display area is important. The three original sections designed for the MNS prototype (menus and buttons, status window, chart display) would be reconfigured as follows: retractable menus, vertical disposition of toolbar, abbreviated status window. These sections would be arranged so that a maximum of display area will be dedicated to chart windows.

The functions would be regrouped under menus that corresponds to the various modes under which the system is used. The following menu categories would be considered:

Chart:	containing chart loading, manipulation, display, and editing functions
Planning:	containing route planning and editing functions
Monitoring:	containing route loading, ship's parameters setting, and alarm and viewing options selection functions
Tools:	containing the tools functions
Sensors:	containing the functions to connect to external devices
Window:	containing all (chart) window manipulation functions
Help:	containing the electronic books and information about the application software version

User inputs
A new menu with appropriate commands needed to be created to allow the user to turn ON the following tools:

- Range ring
- Variable range marker
- Electronic bearing line
- Cursor variable range marker
- Beam bearing

Information entry to be done by the user in support of other functionalities to be provided by the ship-based system prototype were to be included as follows:

- The route editing function was to be combined with the route planning function into a distinctive menu.

- The semi-automatic route planning capability was to be integrated as part of the route planning mode, and was to be the default mode of route planning.

- The distance to waypoint and cross-track error thresholds would be set when doing route planning. These would be entered as waypoints and leg lines attributes of the planned route.

- Setting the position update alarm time threshold would likely not be done on a regular basis. In fact, the setting mechanism should prevent the entering of too large a number which could dangerously delay alarm triggering. Until there is a definite need to change this, the time value for triggering a positioning system alarm (loss of connection) would be set at the factory as 8 seconds. Note that GPS data is normally received every second.

- Setting of the voyage track sampling rate is subjected to the same rules as the position update alarm time threshold; this value would rarely be changed. Ease of access to change this value was therefore not of the highest priority. Setting it in an initialization file for the ship-based system prototype was acceptable.

- The alarm acknowledgment function is very closely related to all alerts and alarms. It would be easy to quickly acknowledge alarms once they have been triggered. For this reason, it would be added to the button bar, thus providing single operator action to acknowledge active alarms.

Positioning status
The following status information from the GPS/DGPS would be decoded by the GPS DLL and distributed by the client module:

- Horizontal Dilution Of Precision (HDOP) (or EDOP and NDOP if HDOP is not available)
- number of satellites tracked
- navigation mode (3D DGPS, 3D, 2D DGPS, etc.)
- beacon frequency
- beacon signal strength

This information was to be displayed in the alarm section of the status panel, but would not be used to trigger GPS failure alarms.

Status panel
As a result of the field trials conducted on the MNS prototype, and the addition of new functionality, the following changes were to be incorporated to the status panel:

- Deletion of the UTC time (to be still available by properly setting the time zone in the Windows NT operating system)

- Deletion of the current chart number (always displayed in the chart window title bar)

- Add the value of the cursor variable range marker in the cursor section

- Add the value of the beam bearing length in the ship section

- Add the value of the range ring radius in the ship section

- Add the value of the rate of turn in the ship section (based on COG if heading is not available)

- Enlarge the character size of the bearing and range information in the cursor section, and of the course over ground, speed over ground, and cross-track distance in the ship section

- Remove and relocate waypoint related information

- Regroup the various alarms into categories

- Add positioning status information (HDOP, satellites tracked, navigation mode, beacon frequency, beacon signal strength) in the alarm section

6.2 Architectural Adjustments

To support the additional types of data to be received, decoded, and handled by the ship-based configuration of the MNS, the Server architecture had to be expanded and structured to provide additional flexibility at a lower level. As a result, the GPS module was renamed the Client module to reflect its growing versatility. Similarly, all the various tools implemented for the first time in the ship-based configuration were included in a new Tools module.
Figure 6-2 provides a diagram of the generic software architecture for the ship-based system. It is worth noting that this architecture is identical to that of the pilot system configuration. This is desirable for ease of development, maintenance, and version control.

6.2.1 User interface module

Changes to MNS prototype version of the UI module were required to support the re-design of the status panel and to include a new data entry box for the dead reckoning function.

6.2.2 Navigation module

In addition to the functionality developed for the MNS prototype, the navigation module also has to support the semi-automatic route planning function, and include the dead reckoning algorithm.

6.2.3 Cartographic module

The capabilities of the Cartographic module were extended for the ship-based system prototype to include: the handling and display of raster charts, the display of the compass rose, and the queries associated with the semi-automatic route planning.
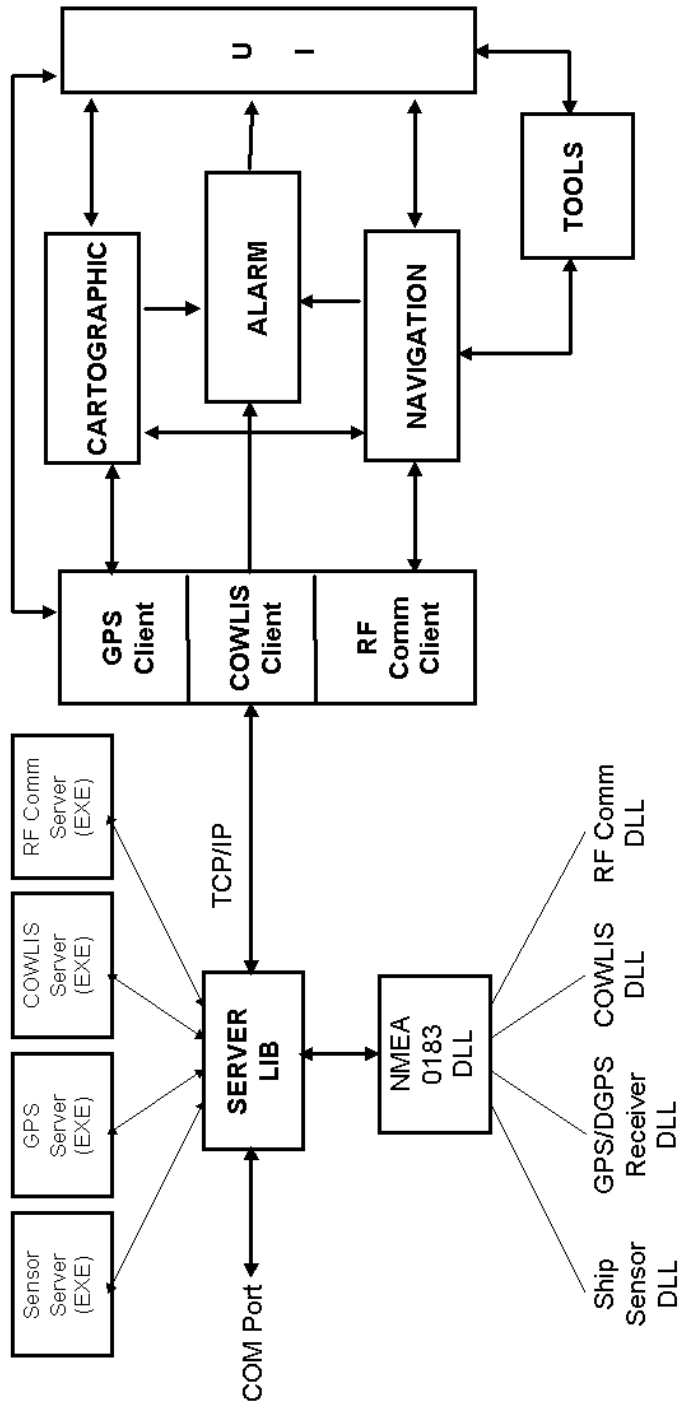
Figure 6-2 - Revised MNS Software Architecture

6.2.4 Tools module

The Tools module was a new module introduced to combine several new functions under one logical identity, thus keeping the specificity of the other modules intact.

The Tools module included a complete and flexible route planning function, and various measuring tools.

6.2.5 Client module

What was known as the GPS module in the MNS prototype architecture was broadened to a more generic Client module. The task of the Client module is to provide data obtained from external sources to other modules. This includes positioning data, navigation mode, Horizontal Dilution of Precision (HDOP), number of satellites tracked, DGPS beacon frequency, and signal strength. Data from the AIS system (other traffic, COWLIS) and other ship's sensors are also routed through this module.

6.2.6 The server

As for the Client module, the Server originally designed for the prototype MNS was modified and turned into a generic server capable of passing messages from a wider variety of peripherals.

All marine equipment communicate through a well-defined standard called NMEA 0183. This standard defines specific sentences for different types of equipment (standard sentences), and also permits the creation of custom sentences (proprietary sentences) that can be defined by the equipment manufacturer.

The Server is to support these types of messages through a Dynamic Link Library (DLL) capable of decoding standard and proprietary NMEA 0183 sentences. It is the Server (LIB) file responsibility to acquire the data from the COM port(s), and transmit it to the NMEA DLL with a request to decode.

The information flow control between the MNS, the Server, and the NMEA 0183 DLL is to be performed by individual peripheral servers. The ship-based system is to be able to communicate with several ship's sensors, and therefore have several peripheral servers with possibly an equivalent number of DLL.

6.2.7 Modules revision summary

Table 6-1 identifies which functions newly introduced on the ship-based system prototype have an impact on a particular module.

Table 6-1 - Modules Revision Summary

UI	Navigation	Cartographic	Alarm	Tools	Client	Server
Status Panel	Semi-automatic route planning	Raster format	GPS failure	Semi-automatic route planning	Navigation mode	Navigation mode
Dead reckoning	Dead reckoning	Compass rose	DGPS failure	Range rings	HDOP	HDOP
		Semi-automatic route planning		Electronic bearing line	Satellites tracked	Satellites tracked
				Variable range marking	Beacon frequency	Beacon frequency
				Cursor variable range marking	Beacon signal strength	Beacon signal strength
				Beam bearing		

7. RADAR INTERFACE DEVELOPMENT

7.1 System Design Description

Considering the importance of a good quality radar scan image, the time and effort required to design and develop new hardware, and the decreasing price of existing radar interfaces, Q-MAR elected to proceed with the development of the radar interface using the TITAN product. Although still expensive at the time, it was expected that the price would be reduced significantly to allow clients to equip their MNS with a high-quality radar interface at a reasonable cost.

Following is a description of how each requirement identified in the Radar Interface System Specification was planned to be implemented into the MNS software.

7.1.1 Radar image

The Modular Radar Interface unit digitizes, scan converts, and filters radar data to produce a bitmap version of the radar sweep and makes it available over a network. The MRI acquires the video information directly from the radar transceiver which ensures good flexibility and compatibility for interfacing to a maximum of radar types. A server which allows the distribution of the radar sweep information to several clients over a network had been developed and was already available. In this configuration, the MNS was to be designated as client.

7.1.2 ARPA data

The great majority of today's radar is equipped with an Automatic Radar Pointing Aid (ARPA) module. This module extracts, from the radar data, numerical information on targets designated by the radar operator. This information is usually available through NMEA 0183 sentences over a serial port complying with either RS-232 or RS-422 communication standard. The MNS was to be capable of acquiring this information and graphically displaying the target on the electronic chart, and providing numerical information for each displayed target.

7.1.3 Overlay

A command was to be added to allow the operator to activate the overlay of the current radar image to the electronic chart.

When the radar image is displayed, both the chart and the radar image display were to be limited to the North-up orientation. This would prevent orientation mis-match due to refresh rate delays and differences between the MNS and the MRI in the treatment of the Head-up display.

An option was also to be added to turn the display of ARPA targets On and Off. Similarly, the user would have the option of having a lost target (deleted as a target on the radar) be erased from the display after a certain period of time.

An ARPA target window was to provide numerical data on the target; its name, speed, course and so on. In addition, it had to be possible to always display at least the target name even if the ARPA window was closed.

7.1.4 Separate window (radar only)

A command was to be added to allow the operator to view the current radar image in a separate window (chart window with no chart data). This command had to be totally independent from the "overlay" command. It had to be possible to view simultaneously the radar image alone, and as an overlay to the electronic chart (into two separate windows).

7.1.5 Symbols and colors

The VESSEL00 symbol was to be used to display ARPA targets on the electronic chart.

When overlaid to the chart, both the ARPA targets and the radar image were to be displayed using the RADHI color token as defined by IHO's special publication S-52. Since the MRI supplies its radar images in shades of gray, the MNS was to provide for the setting of a threshold to set the turn On/Off point of radar echoes for adjusting the intensity of the display as an overlay to the electronic chart.   Access to the refresh rate was also to be provided for the operator to adjust the intervals between radar image refresh. The refresh value was to be applied in both the overlay mode and the radar only mode.

Because no chart data would be displayed in a radar only chart window, radar image quality and clarity was to be improved by utilizing as many colors (shades of gray) as possible.

7.1.6 Single action button

A button was to be added or allocated to the MNS to allow the turning On and Off of the radar image. Because ARPA targets were to be displayed with a discrete symbol on the electronic chart and do not clutter chart information, they should be treated separately and not be controlled from the single action button.

7.1.7 Radar antenna offset

An entry was to be added to the configuration menu for sensors to include the location relative to the conning position of the radar antenna.

7.1.8 Ship's position offset

Since all radar images supplied by the MRI are geo-referenced, the requirement to provide the capability of applying a position offset to the vessel so that the radar image will match the electronic chart became obsolete. The radar image was to be displayed on the electronic chart at the location corresponding to the geographic reference of the image. It was therefore independent of the ship's display position on the chart.

7.1.9 Tools

Tools were handled in a global manner, that is, they were always applied in all opened chart windows. However, their visibility in all chart windows was dependent on the point of origin and the range of the tools, and the chart areas being viewed.

Tools available on the MNS and to be supported for the radar interface were:
- Electronic Bearing Line
- Variable Range Marker
- Cursor VRM
- Range Rings
- Compass Rose
- Beam Bearing

A chart window containing only a radar image (no chart data), was to be treated as a regular chart window as far as tools were concerned.

RADAR INTERFACE

INPUTS

Scan image

Bitmap (1024x1024)
Lat/Lon

ARPA

ID Number
Range
Bearing
SOG
COG
Distance to CPA
Time to CPA

User

Display Mode (Overlay/Radar only)
Palette Threshold
Refresh Rate
ARPA Targets Display
ARPA Data Display
Electronic Bearing Line
Variable Range Marker
Cursor VRM
Range Rings
Compass Rose
Beam Bearing

OUTPUTS

Image

Overlay
Radar Only
Electronic Bearing Line
Variable Range Marker
Cursor VRM
Range Rings
Compass Rose
Beam Bearing

ARPA

Display On/Off
ID Number
Range
Bearing
SOG
COG
Distance to CPA
Time to CPA
Bow Crossing
Time to Bow Crossing
Deletion of Target

Figure 7-1 - Radar Interface Functional Design Elements

44

7.2 Software Architecture

The software architecture necessary to support the radar interface followed the pattern of the current MNS software architecture, and supported the client/server model design of the Modular Radar Interface (MRI).

To achieve this, a Radar Module had to be created and dedicated to the handling of all tasks related to the acquisition and control of radar image data. This Radar Module had to interface to the MNS UI module as well as to the MRI Dynamic Link Library (DLL) which handled communications with the MRI Server. See Figure 7-2 for a diagram of the architecture.
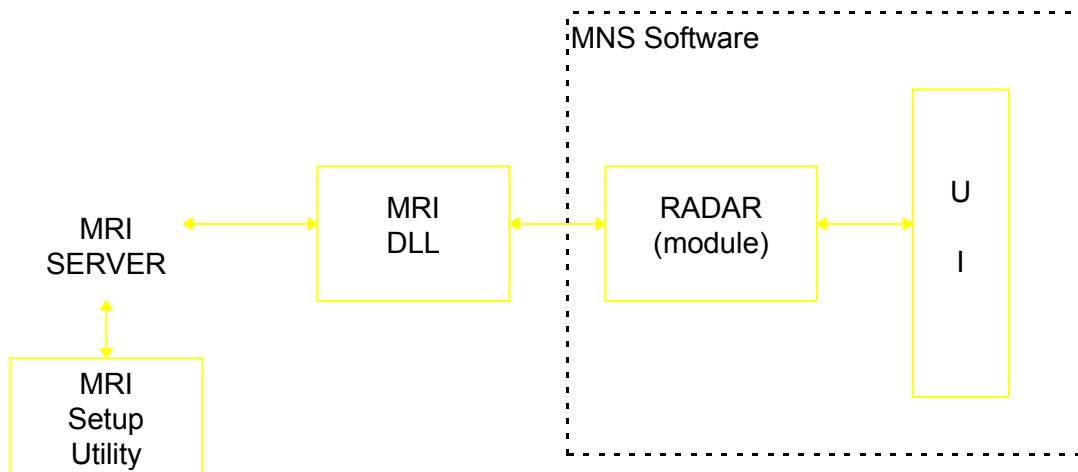
Figure 7-2 - MNS Software Architecture for Radar Scan Interface

The ARPA interface could easily be integrated into the current software architecture of the MNS. The MNS software architecture was specifically designed to facilitate the support of devices communicating per the NMEA 0183 standard. Since ARPA modules output standard sentences and not proprietary ones, a dedicated Dynamic Link Library was not required. All decoding was done within the generic NMEA 0183 DLL.

Figure 7-3 depicts how the ARPA interface was to be added to the existing MNS software architecture.
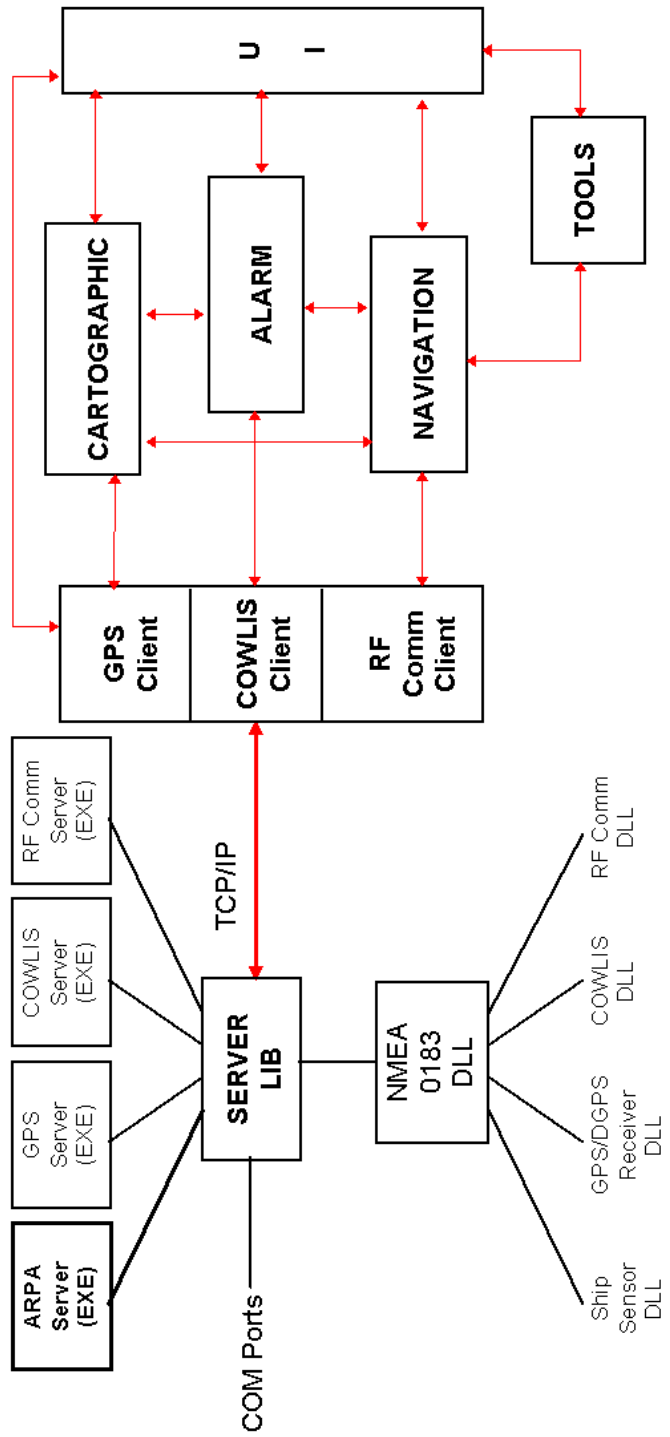
Figure 7-3 - ARPA Integration to MNS Software Architecture

7.2.1 The MRI client/server model

As previously mentioned, the Modular Radar Interface (MRI) data communication and control is based on a client/server model. With this model, the client (the Radar module or the MRI Setup Utility) sends requests to the server via a network. The server is then responsible for handling these requests and sending back responses. All client/server communications are done via a network protocol known as Remote Procedure Calls (RPCs).

However, to facilitate the development of client communications with the MRI Server and to get away from the intricacies of network protocols, a special Dynamic Link Library (DLL) was developed. This DLL was to be used by the client application to communicate to the MRI Server. The MRI DLL presented a series of standard Application Programmers Interface (API) calls which had the noticeable advantage of providing some "design" isolation between the server and the client. In other words, hardware and software changes to the MRI would be totally transparent to the client application as long as communications pass through the DLL which acted like a buffer.

The MNS was considered a client application of the MRI and was to communicate through the MRI DLL.

7.2.2 Radar module

The Radar module was to work on a threaded process which started when a radar display mode was selected for a chart window. With this process, the thread waited for the next scan/radar image from the server that satisfied the radar image refresh rate set by the user. It compared the time difference between the last image that it received from the server and the newest available scan. When the time difference was greater or equal to the radar image refresh rate, it acquired the latest scan from the server and signaled the MNS that a new radar image was available.

Only one radar thread was to be running at a time. A semaphore kept a count of how many chart windows were using the radar display. When this count reached zero (no windows were displaying the radar image), the radar thread was no longer required and was stopped.

7.2.3 UI module

The existing User Interface module of the MNS was to be modified to incorporate the windows, dialog boxes, and commands necessary to support the radar interface. The tasks and operations performed by the UI module were to remain the same as for the generic MNS.

47

7.3 Hardware Design

The selection of the TITAN radar interface technology simplified the integration of radar interface capability to the MNS. Figure 7-4 summarily depicts the interconnections and interfaces between the MRI and the MNS.

Of course, no supplementary hardware is required for the interface to the radar ARPA module.
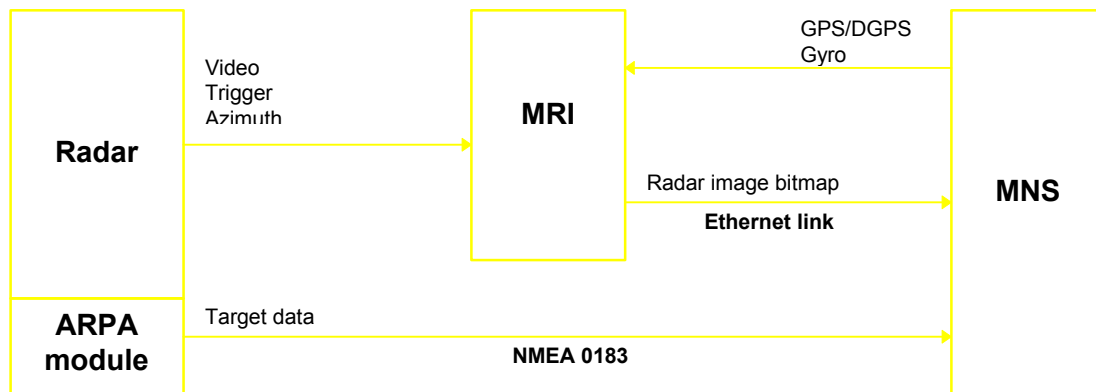
Figure 7-4 - Radar Interface Interconnections

The required inputs characteristics for the MRI were as follows:

Video: any analog signal from -10 volts to +10 volts
Trigger: positive or negative going trigger signal up to 10 volts
Azimuth: synchro, resolver, or digital data
Gyro: stepper
GPS: NMEA 0183 sentences GLL, GGA, RMA, or RMC

7.3.1 Computer

Early investigation on the performance of the MRI indicated that the MRI Server took up a lot of CPU time for operation. A separate computer, dedicated to the radar interface, had to be considered. The minimum requirements for such computer were as follows:

- Pentium Processor
- Windows NT 3.5 Operating system
- 10MB RAM
- 188KB Free hard disk space
- Two free ISA expansion slots to mount the TITAN cards
- One free expansion slot for an ethernet network card

Since the MRI computer needed a keyboard to boot up just as any other computer, a dedicated keyboard/mouse combination had to be made available for the MRI. For the MRI to share the system's monitor and hence facilitate troubleshooting and maintenance, a video switch had to be added.

7.3.2 Console mounting

The MNS console design had to include provision for the mounting of the MRI computer, its keyboard and mouse, and a video switch.

8. FINAL SOFTWARE PRODUCT

The changes described above were incorporated into the system software to generate the final version which would be subjected to formal testing. The following paragraphs describe in detail, from a user's perspective, the MNS software application.

8.1 Main Window

The MNS screen consists of a Main window that is divided into four distinct areas; the toolbar, the chart viewing area, the Status window, and the Message window. Figure 8-1 depicts the MNS Main window as it appears at power up, and identifies all four areas.

The Main window also contains two buttons which are not part of the toolbar; the **Route** and **Messages** buttons are located in the lower part of the main window.

8.1.1 The toolbar

The toolbar area consists of 15 buttons that provide access to all available functions.

The most common functions are provided as single operator action through well identified specific buttons, whereas the rest of the functions are accessible through the **Menu** button.

8.1.2 The chart viewing area

The chart viewing area is where chart windows, containing one or several electronic nautical charts, are being displayed. Up to 16 different chart windows can be opened and displayed at the same time in the chart viewing area.

8.1.3 The status window

The Status window located on the right hand side of the main window provides information on the current date and time, the cursor's location and attitude relative to the ship, the ship's location and attitude relative to the route, and the alarms status.

The information in this window is updated every second.

Toolbar

Chart Viewing Area

Status Window

Route Button

Message window

Messages Button
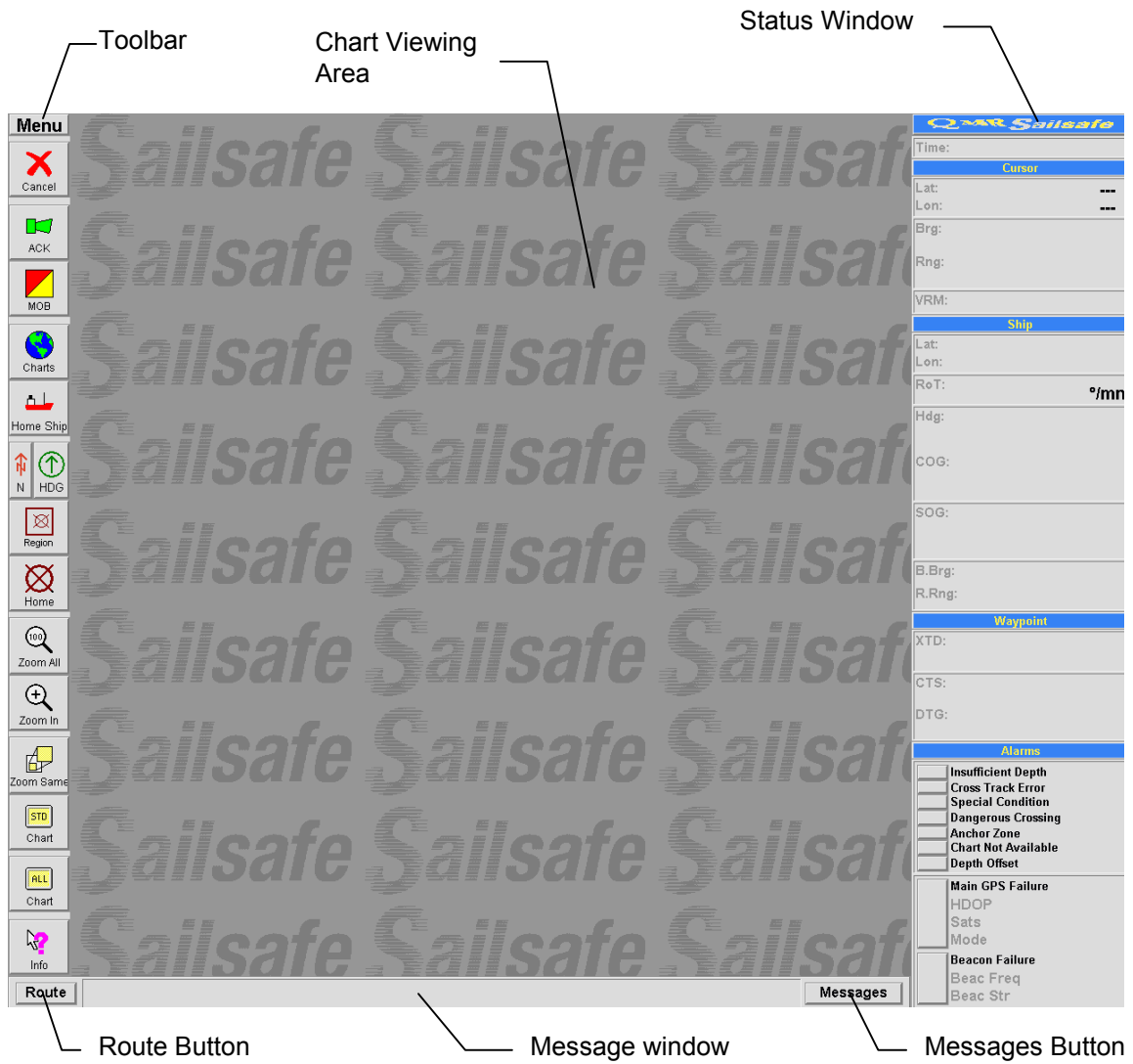
Figure 8-1 - MNS Main Window

8.2 The Menus

The MNS contains a full menu system that is simple to use, flexible, and uses a minimal amount of screen space. The menu system consists of nine pull-down menus that can be revealed by clicking the **Menu** button of the toolbar (see Figure 8-2).

Pin button

Handle

| Main | Charts | Tools | Display | Markers | Tide | Routes | Sensors | Config | Help |
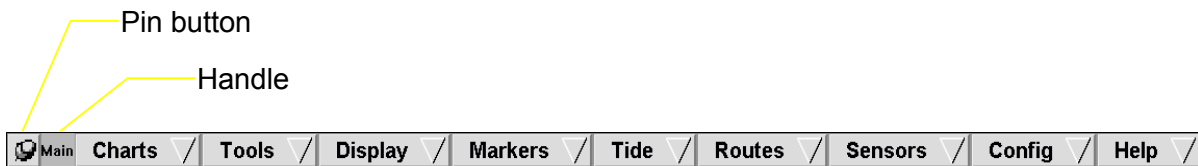
Figure 8-2 - Menu Bar

This menu bar can be "pinned" to the main window by clicking the pin button (appearance of the button will change to show the pinned down condition), and can be moved by dragging the **Main** handle. To close the menu bar, click on the pin in button. Any of the nine pull-down menus can be pulled-down by simply clicking on its title box.

Pinning, moving, and closing pull-down menus are accomplished the same way as for the menu bar, even if the menu bar is itself closed.

The content of each menu is detailed below.

8.2.1 Chart

This menu provides access to all the functions related to charts, such as loading, adjusting the level of information being displayed, and editing (see Figure 8-3).
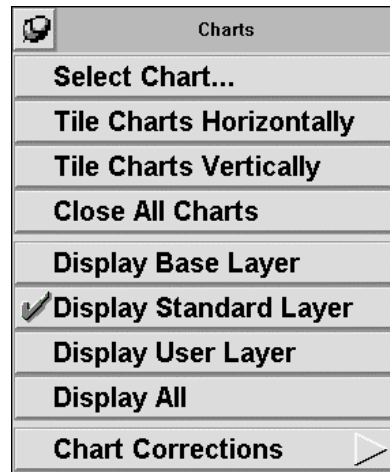
Figure 8-3 - Chart Menu

Select chart...

This command displays the Open dialog box for the selection of a chart to be opened (see Figure 8-4).
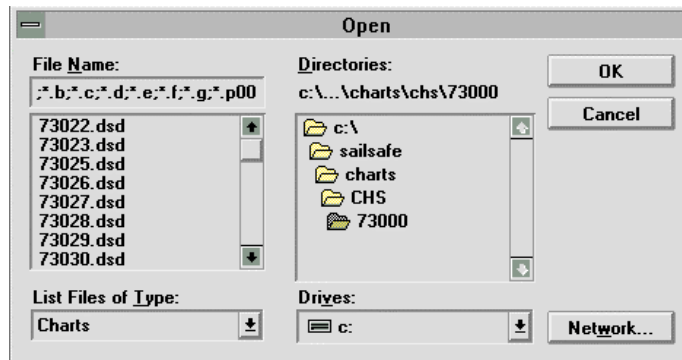
Figure 8-4 - Open Dialog Box

The **OK** button is used to load the chart whose number appears in the File Name box.

The **Cancel** button closes the Open dialog box without loading a chart.

The **Network** button gives access to network connectivity if the shipboard installation consists of several workstations.

Although it can pop up from various commands in the menus, the Open dialog box always assumes the same appearance, and is always used the same way.

Tile charts horizontally

The Tile Charts Horizontally command tiles all opened Chart windows horizontally with the active window to the left.

Tile charts vertically

The Tile Charts Vertically command tiles all opened Chart windows vertically with the active window at top row.

Close all charts

The Close All Charts command closes all opened Chart windows.

Display Base Layer

The Display Base Layer command displays the electronic chart(s) with the minimum amount of information as defined by IMO/IHO S-57 specification. Note that the chart information displayed in the base layer is deemed by IMO/IHO to be insufficient for safe navigation.

Display standard layer

The Display Standard Layer command displays the chart(s) contained in the active chart window (identified by its blue title bar) with standard information. The standard information level is the one first displayed upon chart window opening. The level of information in the standard level cannot be changed.

This command is equivalent to the **Chart (STD)** toolbar button.

Display user layer

The Display User Layer command sets the level of chart information in accordance with user selected display groups from the User Layer Options dialog box.

Display all

The Display All command selects the display of all the information encoded into the electronic chart(s).

This command is equivalent to the **Chart (ALL)** toolbar button.

Chart corrections

The Chart Corrections editor provides the tools to manually update available charts in accordance with the rules defined by IMO/IHO (see Figure 8-5).
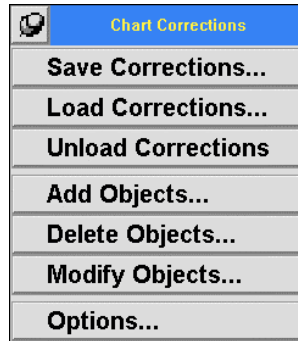
Figure 8-5 - Chart Corrections Sub-Menu

Save corrections...

The Save Corrections... command displays the Save As dialog box to allow the saving of user entered corrections under a user selected file name (see Figure 8-6).
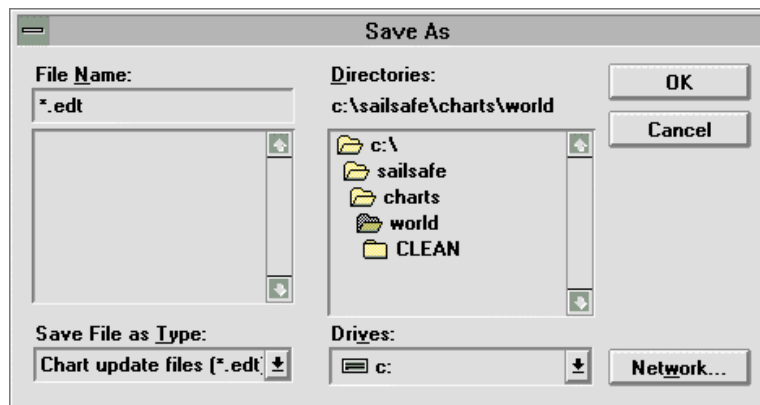
Figure 8-6 - Save As Dialog Box

The Save As dialog box is identical to the Open dialog box except that it creates a new file instead of extracting an existing one. The fields and buttons definitions are exactly the same as for the Open dialog box.

Although it can pop-up from various commands in the menus, the Save As dialog box always assume the same appearance, and is always used the same way.

Load Corrections...

The Load Corrections command displays the Open dialog box (see Figure 8-4) for the selection and loading of previously entered chart updates. Typical file extension for updates is .edt.

Unload corrections

The Unload Corrections command erases from the display of chart corrections loaded with the Load Corrections command. Note that corrections thus unloaded are not erased from memory.

Add objects...

The Add Objects command opens the Add Objects window giving access to all the functionality necessary to add objects, lines, and areas to loaded charts (see Figure 8-7).
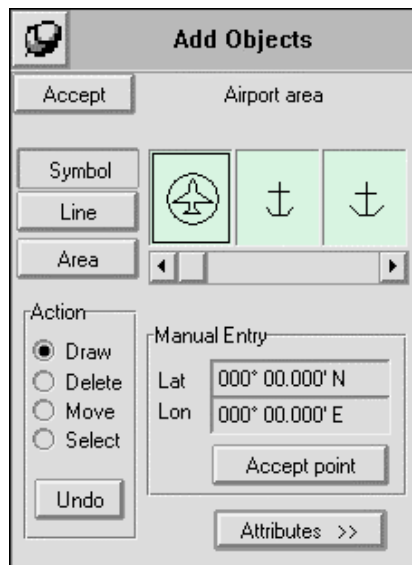
Figure 8-7 - Add Objects Window

The **Accept** button is used to enter an object addition to a chart. Each object added to a chart must be accepted individually.

The **Symbol**, **Line**, and **Area** buttons are mutually exclusive, that is only one can be selected at a time. By default, the **Symbol** button is selected. These buttons determine the type of objects to be added to the chart.

The three graphic boxes show, in alphabetical order, the graphic representation of the symbol, line, or area selected for addition. The name of the object selected is also indicated directly above the graphic boxes. The scroll bar underneath the graphic boxes allows to scroll laterally and graphically the list of objects that can be added to the chart.

The **Action** section provides access to the following drawing functions necessary to perform graphical chart updates. These functions remain active for an object until it is **Accept**ed.

Draw - draws directly on the chart (using the pointing device) the location of the symbol or the periphery of the line or area to be added.

Delete - deletes a point delimiting a line, area, or symbol location as added using the draw command.

Move - grabs a point delimiting a line, area, or symbol location as added using the draw command, and move it using the cursor.

Select - selects a point delimiting a line, area, or symbol location as added using the draw command without the need to alter it. This is useful for obtaining attributes information on certain points.

The **Manual Entry** sections permits to perform actions on very precise points entered manually in latitude and longitude. The **Accept point** button when clicked provides the means to accept the location manually entered.
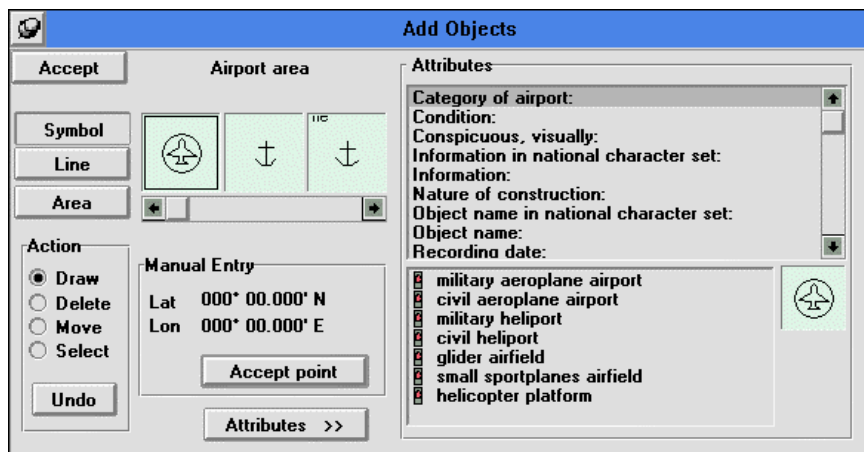
Figure 8-8 - Add Objects Window with Attributes Section

The **Attributes** >> button displays the attribute section of the Add Objects window, giving access and the possibility to add specific details about the object being added (see Figure 8-8). All attributes for an object are listed in the top section, whereas the possible values for the selected attributes are listed in the lower section if applicable. Another graphic box at the bottom of the section clearly indicates the graphic representation of the object selected for addition.

Delete objects...

The Delete Objects... command opens the Delete Object window, as depicted in Figure 8-9, permitting the deletion of chart objects.

It should be noted that the deletion of an object that was added manually using the chart editor will result in its erasing from the chart, whereas the deletion of an object contained in the chart source data will be represented by an orange oblique through the object. This way, original hydrographic data always remain visible on the chart.

The **Delete** button activates the delete action on selected object.
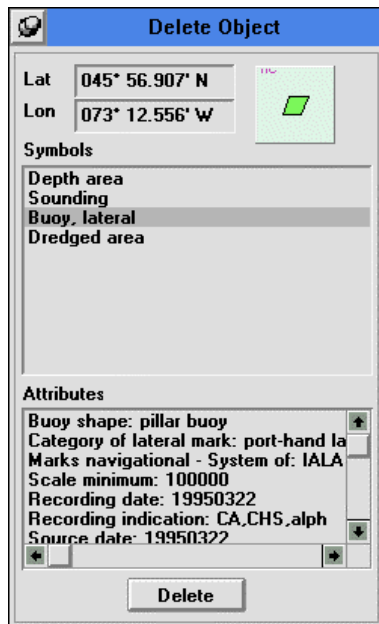
Figure 8-9 - Delete Object Window

Modify objects...

The Modify Objects command opens the Modify Object window which allows the selection and modification of chart objects. Upon opening, the Modify Object window assumes the appearance shown in Figure 8-10. In this state, the window allows for the selection and identification of the chart object to be modified.
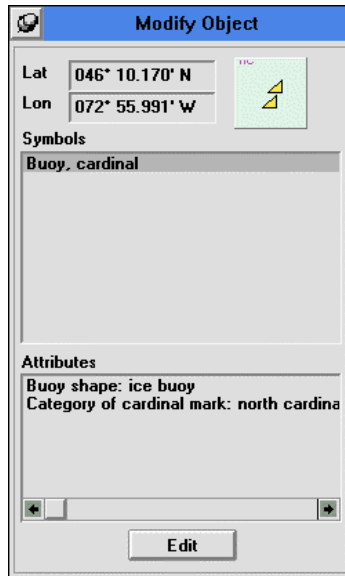
Figure 8-10 - Modify Object Window (state 1)

The **Edit** button accepts the object selection and displays the next state of the Modify Object window which is essentially identical to the Add Objects window.

After the **Edit** button has been selected, the next state of the Modify Object window appears. In this state the dialog box is identical to the Add Objects window, except that if original chart data is being edited, only the **Move** function of the Action section is active. All other buttons act exactly as described in the Add Objects... paragraph.

Options...

The Options command displays the dialog box shown in Figure 8-11below, which allows for the selection of chart updates loading method.
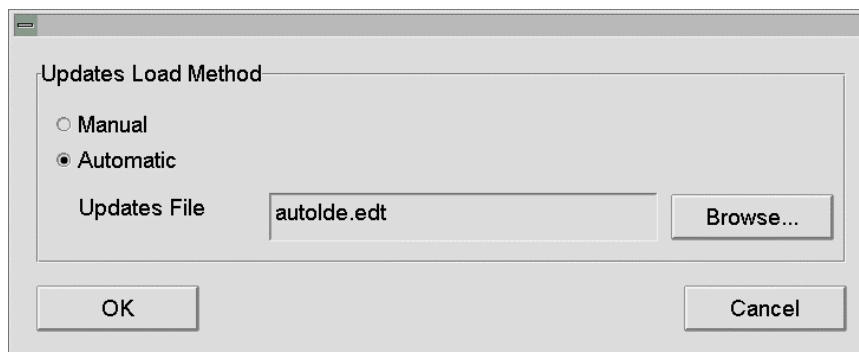
Figure 8-11 - Chart Corrections Options Dialog Box

When the **Manual** load method is selected, chart corrections will only be loaded and applied to opened charts after the operator has selected the Load Corrections... command from the Chart Corrections sub-menu. Similarly, chart corrections entered by the operator using the Add Objects..., Delete Objects..., or Modify Objects... commands can only be saved by going through the Save Corrections... command.

When the **Automatic** load method is selected, chart corrections contained in the file identified in the **Updates File** field (autolde.edt by default) will automatically be loaded and applied to opened charts. The automatic load method also implies that chart corrections performed by the operator will automatically be saved under the same file name upon termination of the chart editing session.

The **Browse** button displays the Open dialog box, giving access to a list of all chart corrections files.

The **OK** button activates the selected load method and closes the dialog box.

The **Cancel** button closes the dialog box without activating any changes that may have been entered.

8.2.2 Tools

The Tools menu provides access to several commands to turn ON or OFF tools designed to facilitate the measurement of distances and bearings on the chart. These tools are simultaneously displayed in all opened chart windows. Activated tools are indicated by a check mark to the left of the menu button name. Figure 8-12 shows the Tools menu with activated EBL and Cursor VRM tools.
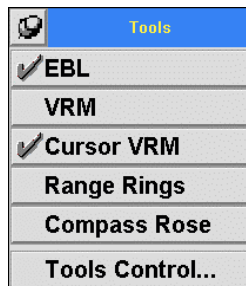
Figure 8-12 - Tools Menu

EBL

The Electronic Bearing Line tool attaches a rubber band between a selected point and the cursor. By default, the point of origin is the ship. The length and bearing of the EBL are indicated in the **Cursor** section of the Status Window under **Rng:** and **Brg:** respectively.

VRM

The Variable Range Marker tool displays a circle centered on a selected point, and of point to cursor radius. By default, the center point is the ship. The radius of the VRM is indicated in the **Cursor** section of the Status Window under **Rng:**.

Cursor VRM

The Cursor VRM tool displays a circle of adjustable radii centered on the cursor. The radius of the Cursor VRM can be adjusted from the keyboard numerical keypad.   The radius of the Cursor VRM is indicated in the **Cursor** section of the Status Window under **VRM:**.

Range rings

The Range Rings tool displays three circles of adjustable radius centered on a selected point. By default, the center point is the ship. The radius of the range rings can be adjusted from the keyboard numerical keypad. The radius of the first (smallest) ring is indicated in the **Ship** section of the Status Window under **R.Rng:**. The radii of the second and third rings are 2 and 3 times that of the first ring respectively.

Compass rose

The Compass Rose tool displays a fixed size circle with 5° markings on its perimeter and identification of every 45° intervals. The Compass Rose is by default centered on the ship, but can also be displayed anywhere on the chart window.

Tools control

The Tools Control command opens a corresponding window giving access to **incr**ease and **decr**ease buttons to adjust the size of the Range Ring, Cursor VRM and Beam Bearing tools (see Figure 8-13). (Note: the Beam Bearing option can be found under the **Ship Display Options** command of the **Display** menu)
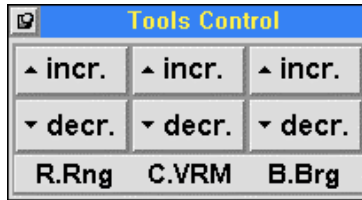
Figure 8-13 - Tools Control Window

8.2.3 Display

The Display menu provides access to all the options related to the display of chart objects and other objects overlaid to the charts (see Figure 8-14).
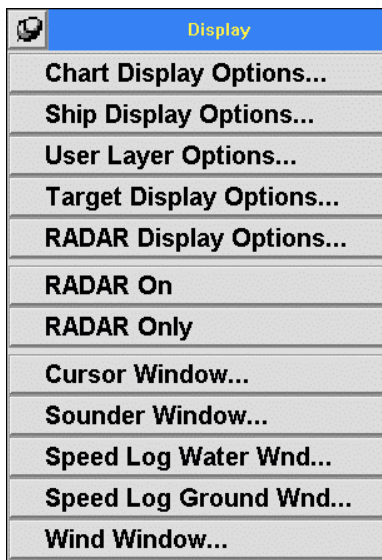
Figure 8-14 - Display Menu

Chart display options...

The Chart Display Options command displays a corresponding dialog box which allows for the selection of desired color palette (according to ambient lighting) and of other options affecting the appearance of displayed charts (see Figure 8-15).
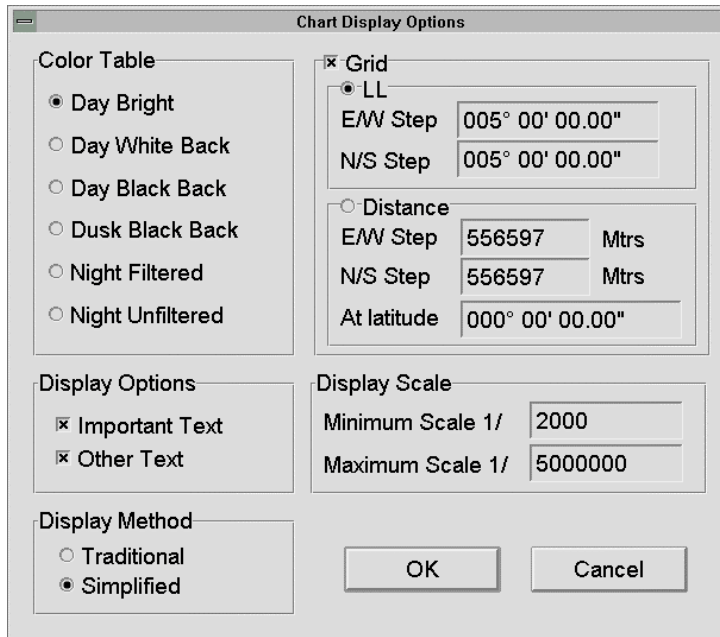
Figure 8-15 - Chart Display Options Dialog Box

The Color Table permits to select one of the six possible color tables corresponding to the following conditions:

Day Bright -   for bright ambient lighting conditions
Day White Back -   for soft ambient lighting conditions
Day Black Back -   for low ambient lighting conditions
Dusk Black Back -   for very low ambient lighting conditions
Night Filtered -   for dark ambient lighting conditions
Night Unfiltered -   for pitch dark conditions

The Display Options provides the option to select the text to be displayed in accordance with its classification as defined by IMO/IHO:

Important Text -   text associated with vertical clearances, bearing of leading line,
                      identification and communication channel of calling-in point.
Other Text -   all other object-associated text

The Display Method affects the appearance of objects on the electronic chart. Two methods are available:

Traditional -   displays objects using paper chart symbology
Simplified -   displays objects using the DX90 presentation library

The Grid option, when activated, will overlay to the chart graticules at intervals entered by the user in either the LL or Distance section as follows:

LL - East/West and North/South graticule intervals are entered in the edit field in degrees, minutes and decimal minutes or seconds and decimal seconds, depending on the units of measures selection in the Config menu.

Distance - East/West and North/South graticule intervals are entered in the edit field in nautical miles or metres depending on the units of measures selection in the Config menu. The At Latitude field allows the user to enter a latitude value that will ensure minimum distortion of distances for the projection of the grid.

The Display Scale section sets a maximum and minimum viewing scale for all charts regardless of their compilation scale.

Minimum - The MNS will not zoom in to a scale larger than the one indicated.

Maximum - The MNS will not zoom out to a scale smaller than the one indicated.

Ship display options...

The Ship Display Options command displays a corresponding dialog box which turns On and Off the options described below (see Figure 8-16).
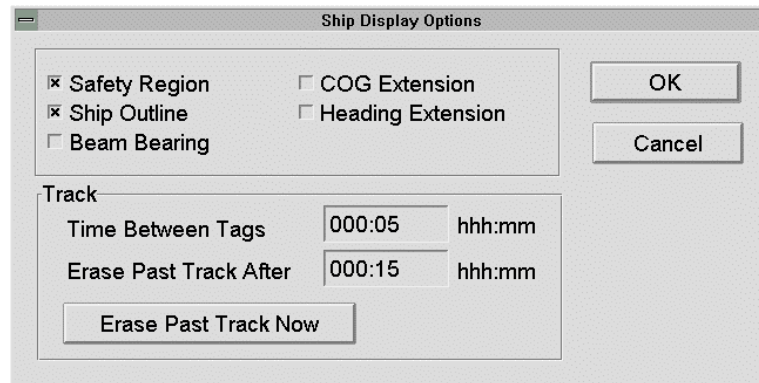
Figure 8-16 - Ship Display Options Dialog Box

The **Safety Region** option displays, on the nautical chart, the vessel's safety region as defined in the Safety Region category of the Vessel Information dialog box.

The **Ship Outline** option displays the vessel as a silhouette with proportions corresponding to the dimensions entered in the Ship category of the Vessel Information dialog box. Note that only the overall length and width of the ship outline is accurate, the shape being

65

standard as defined by IMO/IHO for ECDIS. When the **Ship Outline** is turned OFF (unchecked), the ship is represented as double concentric circles, again as defined by IMO/IHO.

The **Beam Bearing** option displays a perpendicular of adjustable length to ship's centerline. The beam bearing is always attached to the ship. The length of the beam bearing is indicated in the Ship section of the Status Window under **B.Brg:**.

The **COG Extension** option extends the Course Over Ground line to the edge of the chart window. This extension is displayed in orange to indicate that it is user added information and to accentuate the distinction with the IMO/IHO compliant six minutes COG line. Of course, if the COG line already extends to the edge of the chart window, the COG extension is not visible.

The **Heading Extension** option is identical to the COG extension except that it is applied to the heading line.

The Track section contains two entry fields and one button that relate to the display of the ship's past track on the chart.

The **Time Between Tags** option sets the time intervals at which time labels will be attached to the past track.

The **Erase Past Track After** option sets a maximum length to the past track as a function of time. If, for example, the value entered is 15 minutes (as in Figure 8-16 above), only the last 15 minutes of the ship's track will be displayed. Note that this value does not affect the recording of the voyage track into the system "black box".

The **Erase Past Track** button, when clicked, immediately erases the line representing the ship's past track. It does not, however, prevent subsequent past track to be displayed unless the user layer is being displayed and the Past Track object is not selected (under the User layer Options dialog box).

User layer options...

The User Layer Options command displays a corresponding dialog box which allows the user to set, to his/her preference, the display of certain objects when the user layer is selected from the Chart menu (see Figure 8-17).
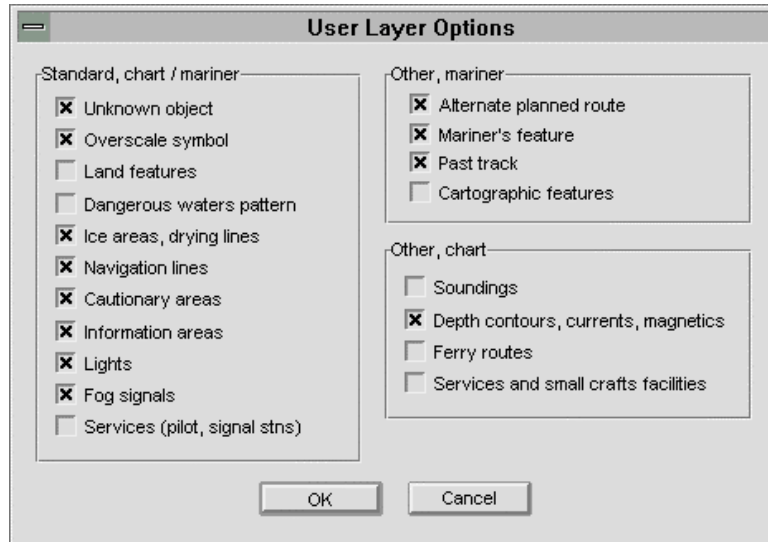
Figure 8-17 - User Layer Options Dialog Box

Target display options...

The Target Display Options command displays the Target Display Options dialog box which provides access to the three ARPA/AIS target options available (see Figure 8-18).
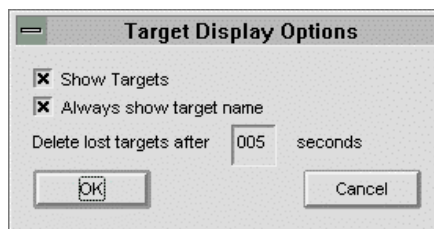
Figure 8-18 - Target Display Options Dialog Box

The **Show Targets** option turns on and off the display of both ARPA and AIS targets.

The **Always show target name** option, when selected, will display the target name or identification next to each displayed target.

The value entered under **Delete lost targets after** xxx **seconds** sets the time interval between target lost and target erasing from the electronic chart display. For example, if the MNS stops receiving data on target ARPA #1, this target will be displayed on the chart for 5 seconds (see Figure 8-18), after which it will be erased from the chart.

Radar display options...

The Radar Display Options command opens the RADAR Display Options window giving access to certain options when a radar interface is available (see Figure 8-19).
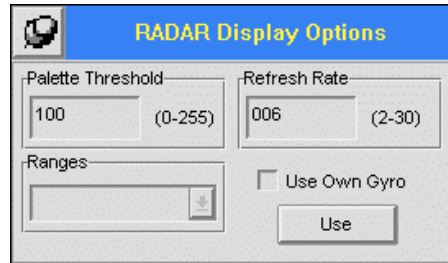
Figure 8-19 - RADAR Display Option Window

The **Palette Threshold** entry allows the setting of the radar image intensity when the radar image is overlaid to the electronic chart (i.e. not in the Radar Only mode). A higher threshold value will reduce the display of weak targets. Valid threshold value ranges from 0 to 256.

The **Refresh Rate** entry set the time interval (in seconds) at which the radar image is to be updated. Valid refresh rate ranges from 2 to 30 seconds.

The **Ranges** list box indicates valid range values for the current radar interface mode.

The **Use Own Gyro** option forces the orientation of the radar image to the heading value displayed by the MNS. This may be useful if a problem exist between the ship's gyro and the radar interface unit.

The **Use** button, when clicked, applies entered values and selected options to the current processing and display of the radar image.

Radar on

The RADAR On command turns on the display of the radar interface on the current chart window. This command is a toggle equivalent to the F11 key. A check mark to the left of the command name indicates that it has been activated. It is necessary to have a radar server (MRI Server) operational and properly connected to the MNS application in order to acquire, process, and display radar images.

Note: When the RADAR On command is activated, the **HDG** toolbar button is grayed out and the only chart orientation mode available is North up.

Radar only

The RADAR Only command erases the electronic chart data from the chart window to leave only the radar image. This command acts as a toggle and can only be applied if the RADAR On command has previously been set. A check mark to the left of the command name indicates that it has been activated.

Cursor window...

The Cursor window command opens the To Cursor window which provides information on a point corresponding to the cursor location relative to the ship (see Figure 8-20). The following information is displayed when the ship is sailing a chart covered area:

ETA: Estimated Time of Arrival of ship

TTG: Time To Go before the ship reaches the cursor considering its present speed but disregarding its course.
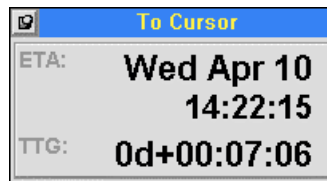
Figure 8-20 - To Cursor Window

The above information is updated in real time as the ship's moves on the chart.

Sounder window...

The Sounder Window command opens the Echo Sounder window which indicates the value of water depth as read from the echo sounder (see Figure 8-21).
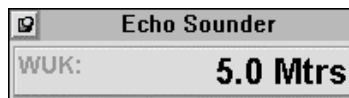
Figure 8-21 - Echo Sounder Window

Note that this command is only available when an interface to the echo sounder is provided.

Speed log water wnd…

The Speed Log Water Wnd command opens the Speed Log Water window which indicates the longitudinal and transversal speed of the ship relative to the water as received from the speed log sensor (see Figure 8-22).
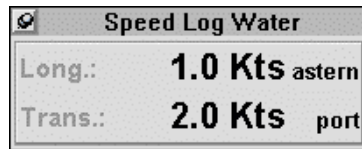
Figure 8-22 - Speed Log Water Window

Note that this command is only available when an interface to the speed log is provided.

Speed log ground wnd…

The Speed Log Ground Wnd command opens the Speed Log Ground window which indicates the longitudinal and transversal speed of the ship relative to the ground as received from the speed log sensor (see Figure 8-23).
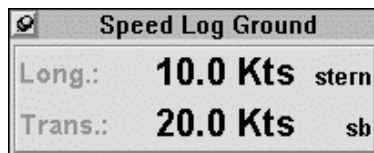
Figure 8-23 - Speed Log Ground Window

Note that this command is only available when an interface to the speed log is provided.

Wind window...

The Wind Window command displays the Wind Indicator window which indicates the wind direction and speed relative to the ship (see Figure 8-24).
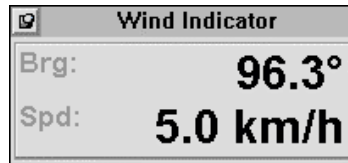
Figure 8-24 - Wind Indicator Window

Note that this command is only available when an interface to the wind sensor is provided.

8.2.4 Markers

The Markers menu provides direct access to prevalent objects for their quick and easy addition to a chart (see Figure 8-25).
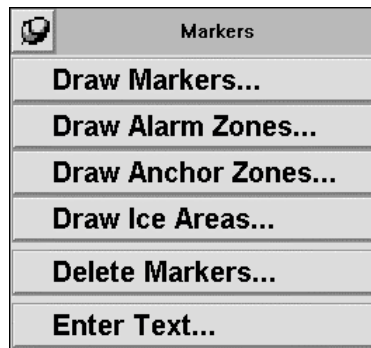
Figure 8-25 - Markers Menu

Draw markers...

The Draw Markers command opens the Draw Marker window which is a subset of the Add Objects window (see Figure 8-26).
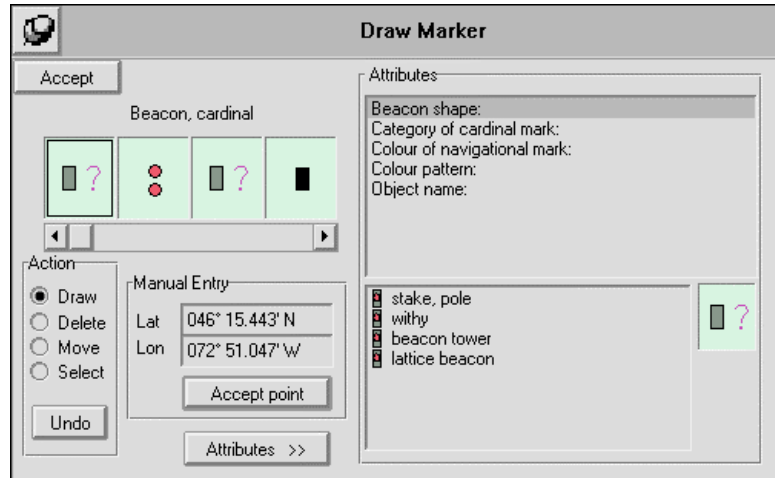
Figure 8-26 - Draw Marker Window

The following objects are available from the Draw Marker window:

Beacon, Cardinal	Buoy, Safe water	Radar reflector
Beacon, Isolated danger	Buoy, Special purpose	Radar station
Beacon, Lateral	Coast Guard Station	Radar transponder beacon
Beacon, Safe water	Control point	Radio calling-in point
Beacon, Special purpose	Danger highlight	Radio station
Building, Single	Fog signal	Rescue station
Buoy, Cardinal	Light	Signal station, Traffic
Buoy, Installation	Light float	Signal station, Warning
Buoy, Isolated danger	Pylon	Tower
Buoy, Lateral	Radar dome	Underwater rock
		Wreck

Draw alarm zones...

The Draw Alarm Zones command opens the Draw Alarm Zone window which is a subset of the Add Objects window (see Figure 8-27).
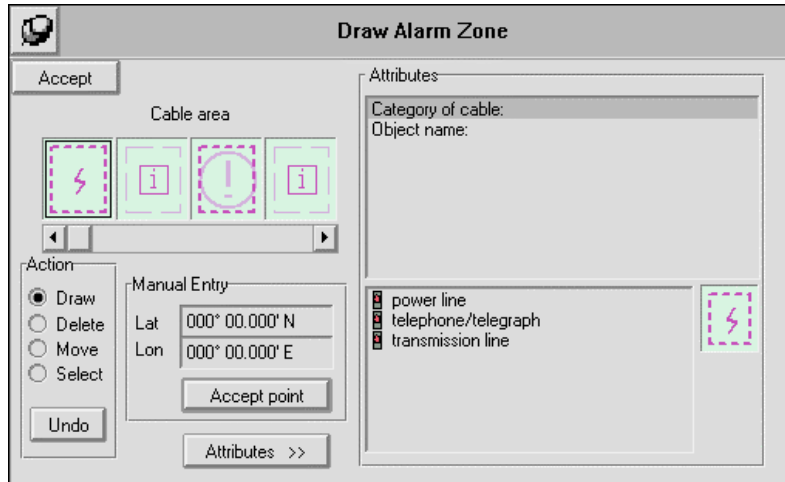
Figure 8-27 - Draw Alarm Zone Window

The following objects are available from the Draw Alarm Zone window:

Cable area	Fairway	Military practice area
Cargo transhipment area	Fishing facility	Offshore production area
Caution area	Incineration area	Pipeline area
Dumping ground	Intertidal area	Restricted area

Draw anchor zones...

The Draw Anchor Zones command opens a corresponding window, which is a subset of the Add Objects window, giving the possibility of adding an own ship anchorage area to the chart (see Figure 8-28). When the ship drops anchor, drawing such an anchor zone around it will set the anchor alarm that will be triggered when the ship's safety region leaves the confines of the anchor zone.
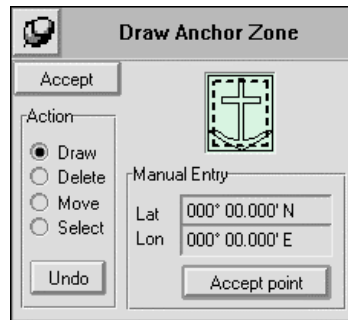
Figure 8-28 - Draw Anchor Zone Window

Draw ice areas...

The Draw Ice Areas command opens a corresponding window box which is a subset of the Add Objects window with only the ice area object available for addition to the chart (see Figure 8-29).
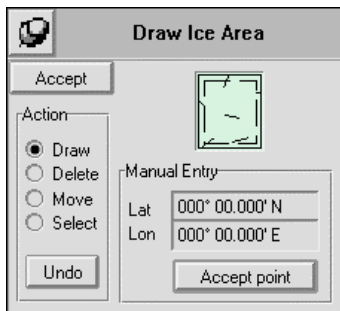
Figure 8-29 - Draw Ice Area Window

Delete markers...

The Delete Markers command has the same functionality as the Delete Objects command, and opens the Delete Object window.

Enter text...

The Enter Text command opens a corresponding window which is a subset of the Add Objects window (see Figure 8-30).
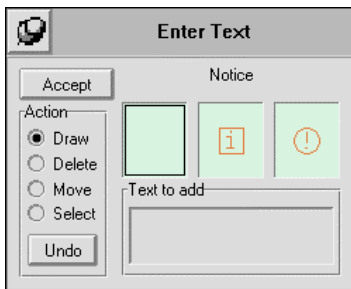
Figure 8-30 - Enter Text Window

The following three types of text can be selected from the graphical boxes and added to the chart:

Notice   Information   Caution

8.2.5 Tide

The Tide menu provides access to two water level offset related commands: Manual Offset, and Automatic Offset (see Figure 8-31). A check mark to the left of one of these commands indicates that it is active. Note that the two types of offset cannot be applied simultaneously.

Figure 8-31 - Tide Menu

Manual offset...

The Manual Offset command displays the Manual Water Offset window which allows the user to enter a discrete value corresponding to a water level above the chart datum (see Figure 8-32). This offset will be applied to all opened charts, which may result in a new definition of the safe water area (displayed in white in day colors). Note that the safe water area is determined from ship's parameters (draught, preferred underkeel clearance) and charts available depth contours. It is therefore possible that an offset will not result in a redefinition of the safe water area.
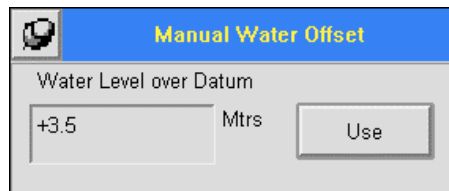
Figure 8-32 - Manual Water Offset Window

Automatic offset...

The Automatic Offset command allows the user to take advantage of the data available through the Coastal and Oceanic Water Level Information System (COWLIS) to have water level offsets applied automatically under route monitoring conditions. This command also has the advantage of facilitating interrogations to COWLIS to obtain only relevant data based on the planned route and estimated time of departure. All this is done through the Automatic Water Level Offsets window shown in Figure 8-33.

Figure 8-33 - Automatic Water Level Offsets Window

The **Date** and **Time** fields indicate the time at which each particular offset will be applied to opened charts. Note that although the time data can be calculated from route ETAs, there is not a one to one relationship between this information and the ETA information displayed in the Route window since water level changes will be applied at a point halfway between stations.

The **Lat**, **lon**, and **Name** fields provide the identification and location of actual Coastal and Oceanic Water Level Information System (COWLIS) sensors installed along the St. Lawrence River, and of any other point manually entered by the user. Note that these fields are not editable for COWLIS sensors.

The **Water Level** field indicates the value of the offset that will be applied at the specified time, and to which sensor or location it corresponds. Presently, these values must be entered manually.

The **ETAs from Route** button activates the calculation of the date and time at which the water level offsets are to be applied based on the route data. It is therefore necessary to

have a route loaded, and have assigned an estimated departure time and ship's speed in the Route window.

The **ETA Now** button forces the time field of selected entry to the current time.

The **Sort By Time** button sorts the list of entries in ascending order. This is useful if a time entry has been changed manually or through the **ETA Now** button.

The **Use** button activates the automatic water level offset function. When it is clicked, it de-activates all other buttons except **Edit**. The Automatic Water Level Offsets window is then said to be in USE mode.

The **Edit** button allows to leave the USE mode and have access to the various fields of the list to perform editions on the entries.

The **Tide Tables** and **Sineco** buttons are not yet active. Eventually, these buttons will perform automatic calculations of water level offsets from either electronic tide tables, or automatic interrogation of the Sineco system. It will then no longer be necessary to manually enter offset values in the Water Level Field.

The **Add Entry** button creates an additional entry to the list. It is up to the user to enter appropriate identification and location for this entry.

The **Remove Entry** button deletes the highlighted manual entry. Note that Sineco sensors entries are protected against deletion and cannot therefore be deleted.

8.2.6 Routes

The Routes menu contains the functions necessary to plan a route and monitor ship's progress against that route when a voyage is undertaken (see Figure 8-34).
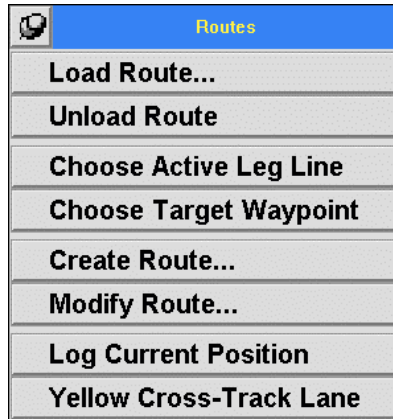
Figure 8-34 - Route Menu

Load route...

Selecting the Load Route... command displays the Open dialog box to allow the selection of the route to be displayed on the chart as the route to monitor.

Unload route

The Unload Route command instantly erases the route loaded on the chart using the Load Route... command. Note that the unloaded route is not erased or deleted from memory, and is thus still available for loading.

Choose active leg line

The Choose Active Leg Line command is used to identify to the system that the loaded route is being sailed. No data on the route or ship's progress against that route can be reported by the system until an active leg line is identified. This action only needs to be performed once at the beginning of the voyage, or every time an alternate route is being sailed.

The name of the route being sailed is indicated in the title bar of the Route window.

Choose target waypoint

The Choose Target Waypoint command directs the system to provide ship's progress against only that particular waypoint. Thus, the status panel will report under the Waypoint section Course To Steer (CTS) and Distance To Go (DTG) data for that waypoint (and not necessarily the current waypoint), but will not report any Cross-Track Distance (XTD) which is measured from a leg line.

Similarly, the route dialog box will provide data only on the target waypoint identified by red lettering.

Create route...

This command displays the Route Planning window which is used to plan a voyage route on opened charts (see Figure 8-35).
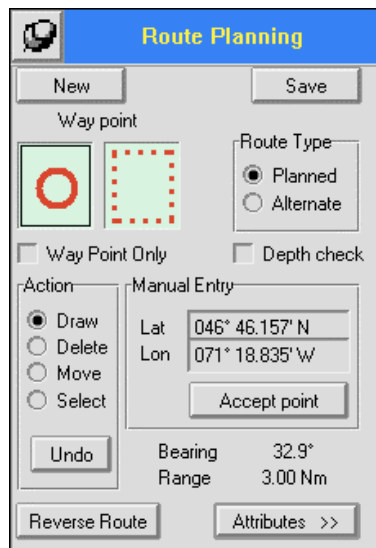
Figure 8-35 - Route Planning Window

The **New** button is used when there is a need to re-start the route planning session with none of the waypoints or legs previously created during the current session. It basically erases what was done so far during the session for a fresh start.

The **Save** button opens the Save As dialog box to allow the saving of newly created route under a user defined file name and directory. Typically, routes would have an .rte file extension.

The **Route Type** section provides for the selection of type of route segment being created between planned or alternate. A planned route is one that constitutes the desired or preferred route to be sailed during the voyage. It appears in red on the chart when loaded for route monitoring purposes. Alternate routes can be extensions, or parallel segments to the planned route that may be sailed if so desired. Alternate waypoints and route segments are displayed in orange on the chart under route monitoring mode when either the User or All Layer is selected.

The two graphic boxes represent the type of waypoint and leg line selected based on the following color coding:

Red - Planned route and leg line

Orange - Alternate route and leg line

The **Way Point Only** option allows the creation of waypoints without attaching leg lines. This can be useful to quickly place on the chart a temporary destination not originally planned on the route, and obtain homing information to that destination.

The **Depth check** option turns On and Off the MNS' automatic verification of sufficient water level for route sailing. When turned On (checked), The MNS will not allow a leg line or a waypoint to be placed where it is unsafe to navigate due to water depths. When turned Off (unchecked), waypoint and leg lines can be placed anywhere on the chart.

The **Action** section provides the same drawing tools as in the Add Objects window.

Draw - draws directly on the chart (using the cursor) the location of waypoints.

Delete - deletes any waypoint that was created using the draw command.

Move - grabs any waypoint and move it using the cursor.

Select - selects a waypoint without the need to alter it. This is useful for obtaining attributes information on the waypoint. The selected waypoint and/or leg line is identified by an unfilled box or rectangle around the waypoint or leg line.

Undo - erases the last action performed in the route planning mode.

The **Reverse Route** button is used to change the sailing direction of the leg lines created so far on the route being planned. An arrow at the leg line mid-point indicates the planned sailing direction. Waypoints created with the **Way Point Only** option ON (checked) do not have a sailing direction. Leg lines added after the **Reverse Route** button was clicked are given the direction of their creation.

The **Manual Entry** section is used to precisely position waypoints by entering desired waypoint latitude and longitude. The **Accept point** button draws the waypoint on the chart.

The **Attributes** >> button displays the attribute section of the Route Planning dialog box thus giving access and the possibility to add or view specific parameters to the waypoints and leg lines being added (see Figure 8-36). Waypoints attributes are displayed when the Waypoint graphic box is selected, and leg line attributes are displayed when the Leg Line graphic box is selected (a black line at the periphery of the graphic box identifies the selected one). All possible attributes for a waypoint or leg line are listed in the top section, whereas the possible values for the selected attributes are listed in the lower section if applicable.
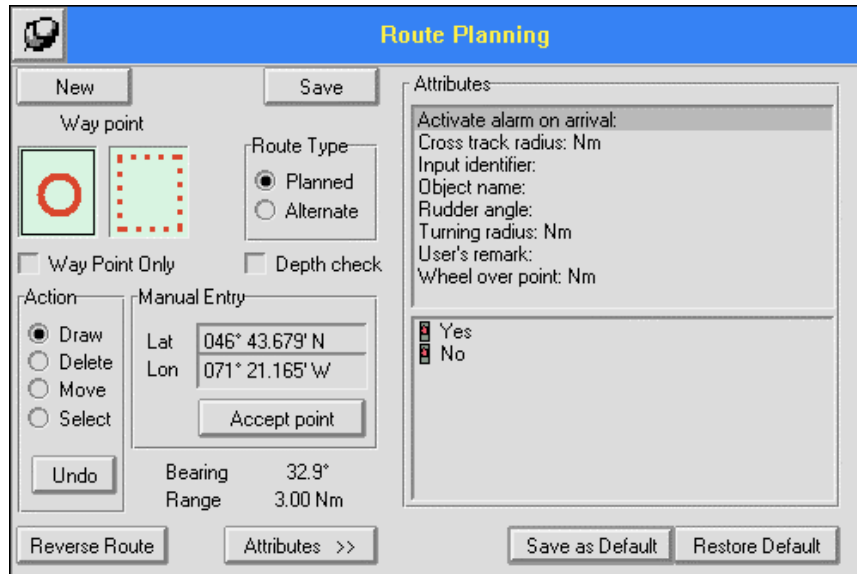
Figure 8-36 - Route Planning Window Box with Attributes Section

The **Save as Default** button permits to establish the parameters to be assigned to certain waypoint and leg line attributes by default. Unless the value of a parameter is changed manually, all subsequent waypoints and leg lines will be given the same attribute parameters. The attributes carrying default values from waypoint to waypoint and leg line to leg line are:

Waypoint: Cross track radius
            Input identifier
            Wheel over point

Leg line: Cross track extent
            Input identifier

The **Restore Default** button allows to go back to the default attribute parameters after manual changes were entered for one or several waypoints and leg lines.

Modify route...

The Modify Route command provides the capability to modify routes already planned and saved in memory. Selecting this command first displays the Open dialog box, and after a route has been selected for modification, opens the Route Planning window and displays the route on the chart as in a route planning mode. The same options used to create the route are made available to modify the route.

Log current position

The Log Current Position command adds an entry to the voyage log file with current time, ship's position, SOG and COG at time of command selection. This entry is in addition to the data recorded in the voyage log file at regular intervals.

Yellow cross-track lane

The Yellow Cross Track Lane command allows to turn On and Off the display of the cross track extent entered in the route planning mode for the current and next leg of the route.

8.2.7 Sensors

The Sensors menu provides some access and control over the connection to peripheral equipment transmitting data to the MNS (see Figure 8-37).

Figure 8-37 - Sensors Menu

GPS...

The GPS command will do one of two things depending on the state of the connection between the provider of data (the server) and the MNS (the client).

Under normal operating conditions, when the GPS receiver is up and running and supplying data, the connection will automatically be established upon start up of the MNS software application. That is, a GPS server is opened and connected to the application through an assigned port number. Under these circumstances, the GPS command will bring the GPS

server "on top" of the electronic chart, thus providing the user with direct reading of all the information received from the GPS sensor.

If no connection exists between the GPS server and the MNS, or the connection is lost, choosing the GPS command will pop up the GPS server dialog box (see Figure 8-38). This dialog box allows the operator to enter the appropriate server machine name and service port number to re-establish communication. Entered information must be valid for the connection to be established.
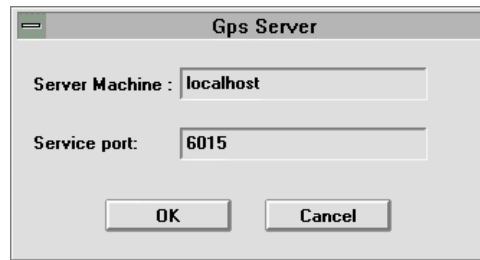
Figure 8-38 - GPS Server Dialog Box

Gyro...

The Gyro command works in the same fashion as the GPS command. It is only active when connection to a gyro compass is provided.

Loran-C...

The Loran-C command works in the same fashion as the GPS command. It is only active when connection to a Loran-C receiver is provided.

ARPA...

The ARPA command works in the same fashion as the GPS command. It is only active when connection to a radar ARPA module is provided.

AIS...

The AIS command works in the same fashion as the GPS command. It is only active when connection to an AIS transponder is provided.

Sounder...

The Sounder command works in the same fashion as the GPS command. It is only active when connection to an Echo Sounder is provided.

Speed log...

The Speed Log command works in the same fashion as the GPS command. It is only active when connection to a speed log sensor is provided.

Wind...

The Wind command works in the same fashion as the GPS command. It is only active when connection to a wind indicator is provided.

Radar...

The RADAR command works in the same fashion as the GPS command to establish connection to an open MRI (Modular Radar Interface) Server.

Dead reckoning...

This command is used to manually open the Dead Reckoning window which permits the entry of own ship Speed, Course Over Ground, and Heading information (see Figure 8-39). Note that under normal circumstances the Dead Reckoning dialog box will open automatically upon failure of the main positioning and secondary (if available) system.

Figure 8-39 - Dead Reckoning Window

Own ship values are entered either in numerical form after clicking on the number to change, or using the slider underneath the parameter (value can be changed by dragging the slider box, or by clicking on one of the end arrows).

The **Manual Val.** button is used when the operator wants the entered and displayed manual heading value to supersede the one received from the gyro compass.

The **Restart DR** button is a toggle that restarts the dead reckoning mode after it has been stopped, or to suspend it (**Suspend DR**) while it's operating.

The **Accept** button, when clicked, forces the usage of indicated Hdg, SOG, and COG values. In other words, if one of these values has been changed, the **Accept** button must be clicked to activate the change.

The **Lat/Lon** button reveals the fields to enter a ship position from which the dead reckoning parameters will be applied.

8.2.8 Config

The Config menu gives access to the system configurations and set-up commands (see Figure 8-40).

Figure 8-40 - Config Menu

Alarms...

The Alarms command displays the Alarms dialog box which allows the setting of audible alarm signature for the different types of alarms (see Figure 8-41).
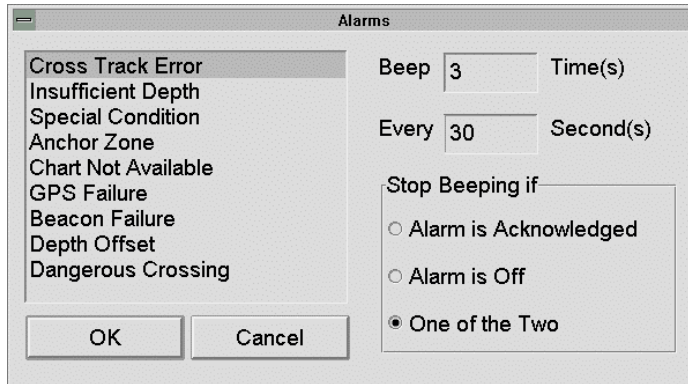
Figure 8-41 - Alarms Dialog Box

The left-hand section of the dialog box lists the various types of alarms for which an audible alarm can be set. The highlighted alarm type parameters are given in the **Beep**, **Every**, and **Stop Beeping if** sections.

The **Beep** section is where the alarm signature is defined in terms of number of beeps.

The **Every** section sets the repetition or reminder rate for the particular alarm (an entry of "0" will turn the reminder off).

The **Stop Beeping if** section contains three options to define under which condition the audible alarm will be stopped:

Alarm is Acknowledged - The audible alarm will stop only after the Acknowledge toolbar button (in NA mode) has been clicked.

Alarm is Off - The audible alarm will only stop when the alarm condition no longer exists (whether the alarm has been acknowledged or not).

One of the Two - The audible alarm will stop if either the alarm is acknowledged or the alarm condition no longer exists, whichever comes first.

Units of measure...

The Units of Measures category contains several sections for the selection of the various measure formats available (see Figure 8-42).
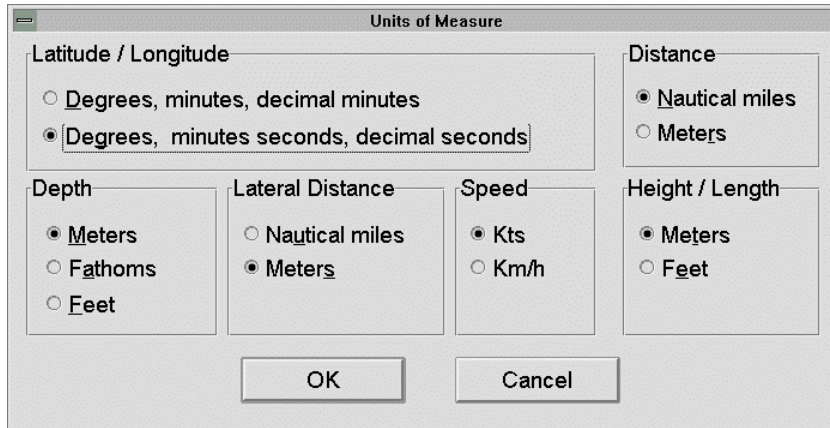
Figure 8-42 - Units of Measure Dialog Box

The **Latitude / Longitude** section provides for the selection decimal minutes or decimal seconds for the precision of measurement of positioning data (applicable to cursor, own ship, and ARPA targets).

The **Depth** section provides the choice of selecting either meters, fathoms, or feet when depth data is displayed. The units selected in this section also apply to the depth information displayed in the Draught dialog box.

The **Lateral Distance** section provides the choice between nautical miles and meters for measurement of the cross track distance and the beam bearing.

The **Speed** section provides the choice between Knots and Km/h for all speed entries and measurements.

The **Distance** section provides the choice between nautical miles and meters for measurement of distances.

The **Height / Length** section provides the choice between meters and feet for measurement of the vertical and horizontal length of own ship and certain chart objects.

Draught...

The Draught command displays a dialog box which allows the user to enter draught and underkeel clearance information to be used by the MNS for safe water determination (see Figure 8-43).
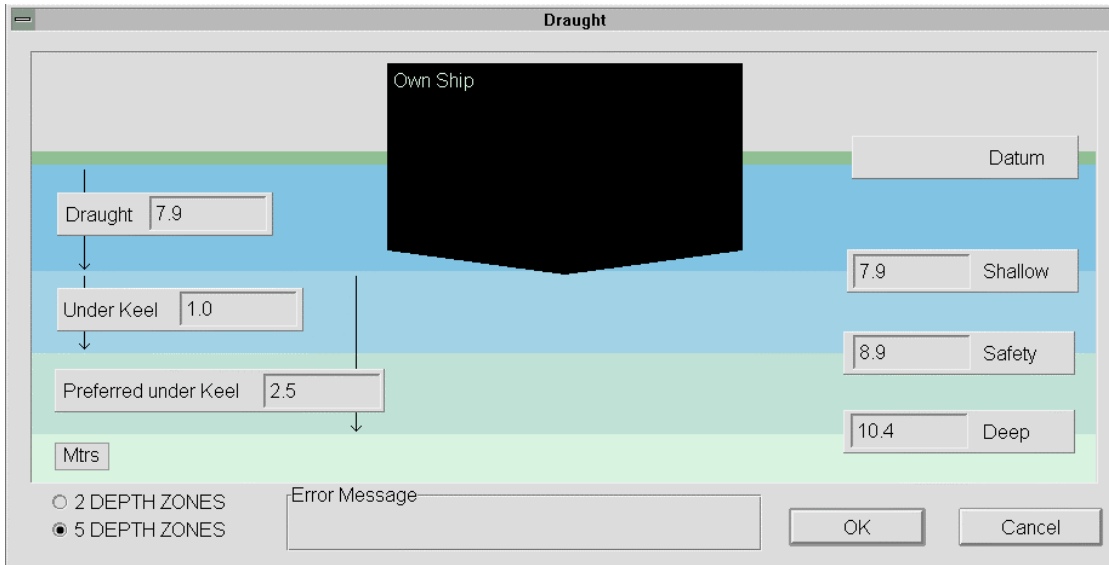
Figure 8-43 - Draught Dialog Box

The colors of the various levels correspond exactly to the colors used in the electronic chart to identify safe and unsafe waters.

The following fields are available to enter the various information:

Draught -   Actual ship's draught. The draught value delimits the Shallow water contour.

Under Keel -   Minimum underkeel clearance required. For example, the squatting effect could be considered in the establishment of the minimum clearance required. This value plus the draught value delimits the Safety water contour.

Preferred under Keel -   Safe underkeel clearance as determined by the user. This value includes the minimum underkeel clearance plus a certain additional safety clearance. The draught value plus the preferred underkeel clearance delimits the Deep water contour.

When values are entered in the above fields, the **Shallow**, **Safety**, and **Deep** contour values are automatically updated upon clicking in the next field. It is also possible to enter values for the **Shallow**, **Safety**, and **Deep** contours which will result in the Draught and Underkeel Clearance fields automatic update.

The **Mtrs** indicates that the units of measures for entered values are meters. It is possible to change the units of measure to feet using the Units of Measure command. In this case, **Feet** or **Fthm** will be displayed instead of **Mtrs**.

The Depth Zones option selects the number of depth zones displayed on the charts to be either 2 or 5. The following depths will be displayed for each selection (in day light color palette):

2 Depth Zones: Shallower than safety contour - Blue
                       Deeper than safety contour - White

5 Depth Zones: Inter-tidal - Green
                       Very Shallow - Blue
                       Shallow - Light blue
                       Safety - Gray
                       Deep - White

The **Error Message** section will inform the user of entries errors in one of the fields of the Draught dialog box.

Own ship info...

The Own Ship Info command displays the Vessel Information dialog box which is a multi-category configuration box. Figure 8-44 depicts the Vessel Information dialog box with the Ship category selected.

Each category can be selected to enter related configuration parameters.
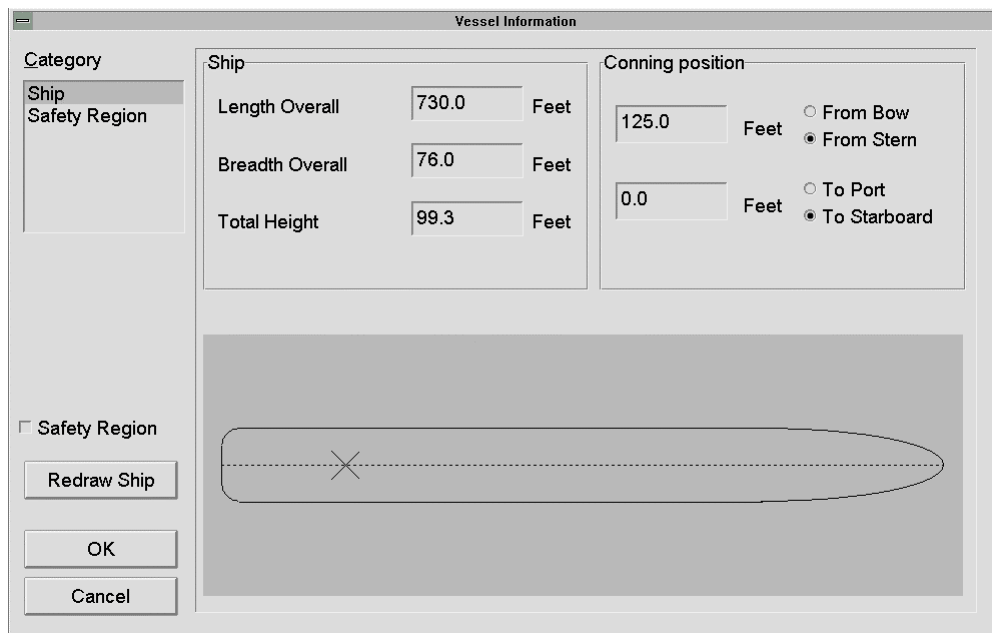
Figure 8-44 - Ship Category of the Vessel Information Dialog Box

Ship category
The Ship category (see Figure 8-44) is where vessel parameters are entered.

The ship's length, breadth and height dimensions are entered in the **Ship** section. The units of measure (meters or feet) can be selected from the Units of Measure command.

Conning station location relative to the ship is to be entered in the **Conning Position** section. An X on the ship's outline in the graphical box provides a visual reference. This information is used by the system to ensure a proper representation of the ship relative to the waterways. It should be noted that when the Ship Outline option is not selected, the double concentric circles vessel symbol represents the ship's conning position.

The **Safety Region** option can be selected to display in the graphical section the vessel and its surrounding safety region. See Figure 8-45.

The **Redraw Ship** button updates the graphical section with the latest entries made in each category of the Vessel Information dialog box.

Safety region category
The Safety Region category is used to enter the dimensions of the minimum safety region and the look ahead region. When this category is selected, the **Safety Region** option is by default ON (checked), and the safety and look ahead regions are displayed in the graphical region of the window.
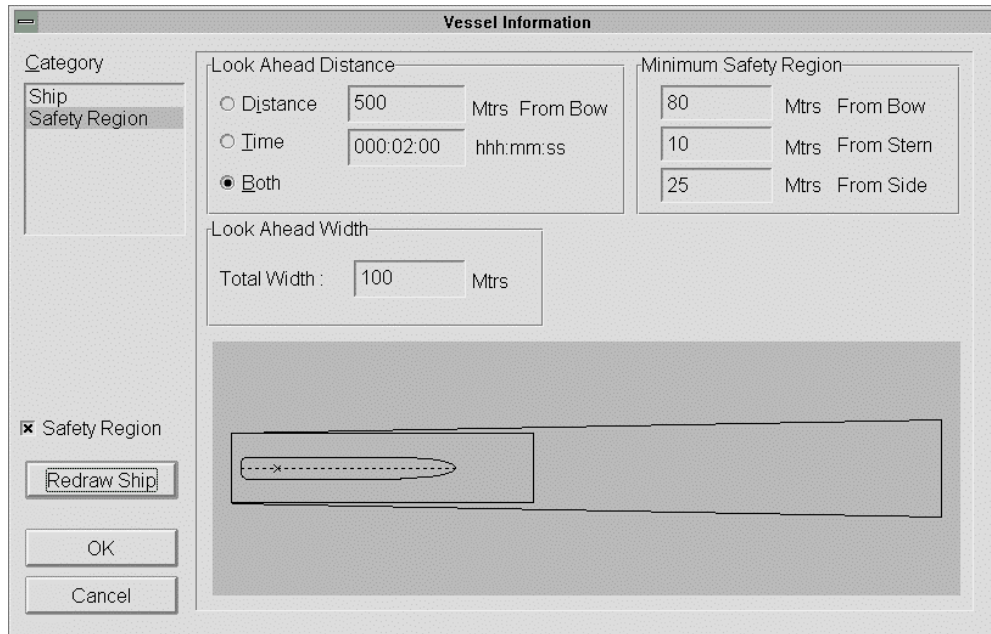
Figure 8-45 - Safety Region Category of the Vessel Information Dialog Box

The look ahead region is an area around the ship where the content of the electronic nautical chart (if of vector format) is constantly being verified for obstructions to safe navigation. The minimum safety region is the smallest possible area to be verified for safe navigation, even if the look ahead region can be set smaller than the minimum safety region. In other words, the verification for obstructions will be performed on the largest of the two regions.

The length of the look ahead region can be set, in the **Look Ahead Distance**, as either an absolute distance, a sailing time, or a combination of both where the longest distance will take precedence. The width of the look ahead distance at its front end, can be entered in the **Look Ahead Width** section.

The dimensions, relative to the ship, of the minimum safety region are entered in the **Minimum Safety Region** section. Again, the results of changing a certain value can be viewed by clicking on the **Redraw Ship** button.

Sensors antennas...

The Sensors Antennas command displays a dialog box which allows to set the position, relative to the ship, of the MNS sensors antennas. Again, this is necessary to ensure an accurate representation of the vessel relative to the chart.
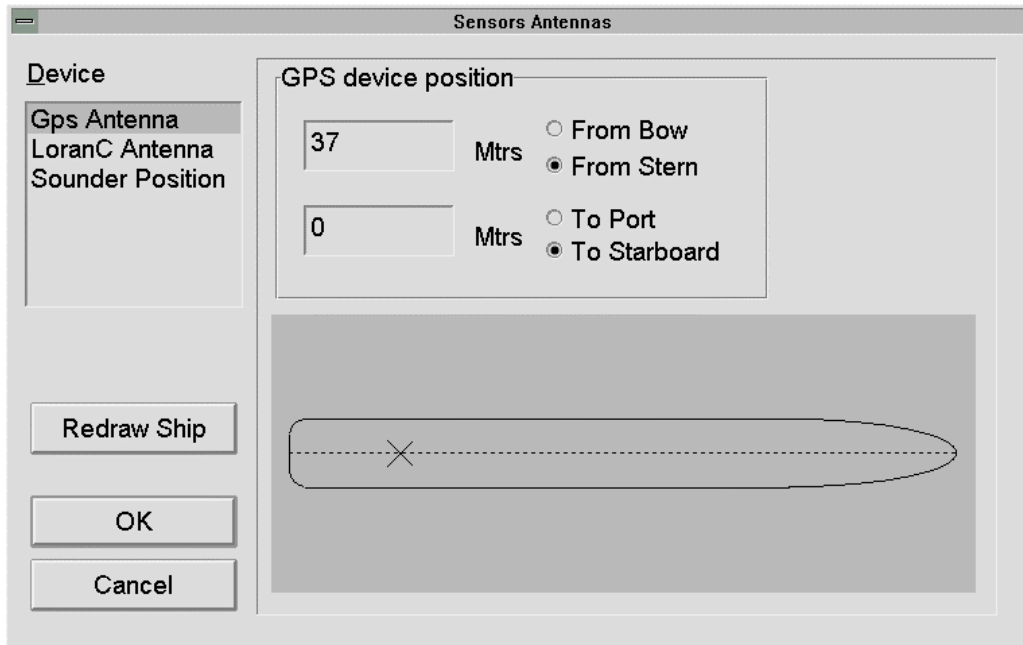
Figure 8-46 - Sensors Antenna Dialog Box

The **Device** section of the dialog box allows each available antenna to be selected individually. In the case of Figure 8-46, only the GPS antenna is shown.

Each category can be selected to enter the position of each available device sensor.

The **Device Position** section provides the entry points to locate the sensor's antenna relative to the ship. This location is also shown as an X in the graphical box.

The **Redraw Ship** button has the same function as for the Vessel information dialog box, it redraws the graphical box in accordance with the latest value entered.

GPS antenna category
The GPS Antenna category allows to enter the precise position of the GPS antenna relative to the ship (see Figure 8-46).

Loran-C antenna category
The Loran-C Antenna category, when selected, changes the appearance of the Sensors Antenna dialogue box to that shown in Figure 8-47 to allow the entry of Loran-C antenna positioning data.
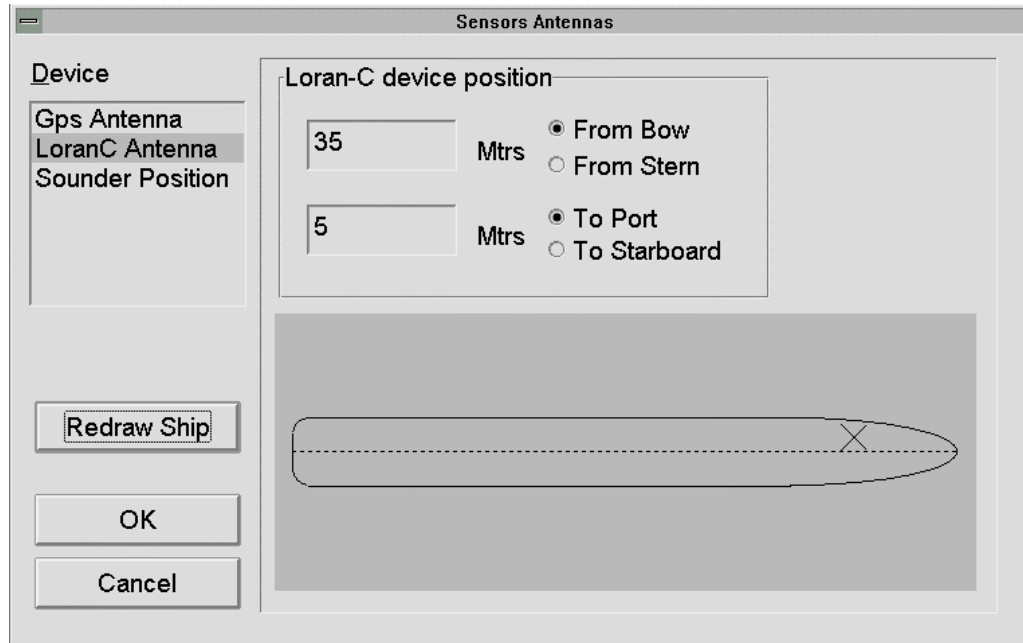
Figure 8-47 - Loran-C Antenna Category of the Sensors Antenna Dialog Box

The position of the Loran-C antenna is entered exactly the same way as for the GPS antenna.

Sounder position category
The Sounder Position category, when selected, changes the appearance of the Sensors Antenna dialogue box to that shown in Figure 8-48 to allow the entry of the echo sounder transducer relative to ship's keel. Of course, this category is only relevant when an interface to the onboard echo sounder is available.
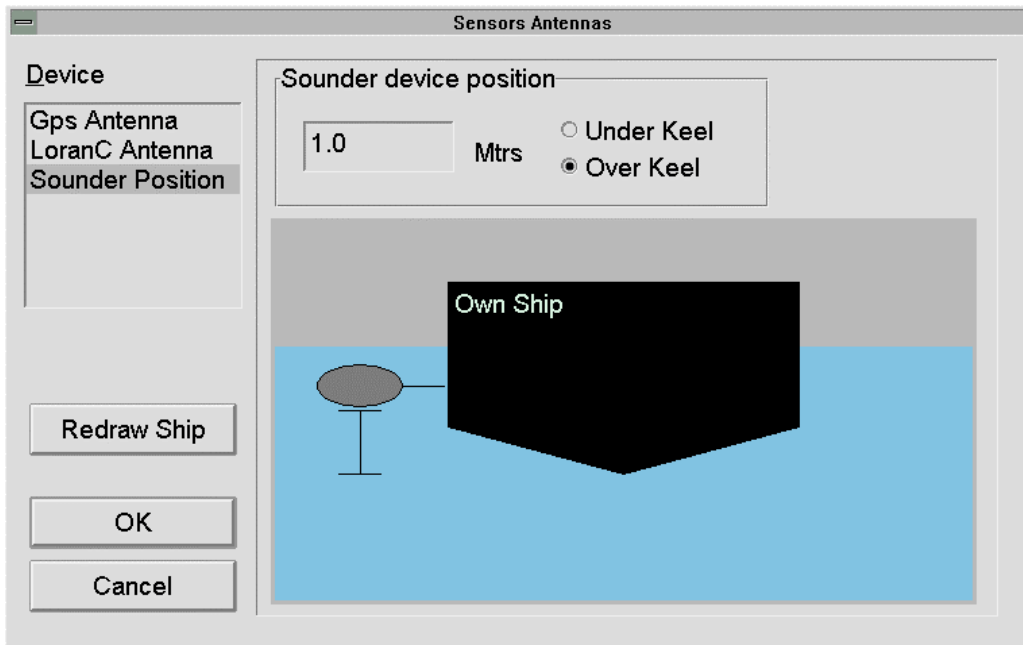
Figure 8-48 - Sounder Position Category of the Sensors Antenna Dialogue Box

The position of the echo sounder transducer is entered relative to the ship's keel. Selecting **Under Keel** in the Sounder device position section allows to enter a position lower (deeper) than the keel's lowest point. Selecting **Over Keel** allows to enter a position higher (shallower) than the keel's lowest point. Entering a value of 0 will result in the same position whether **Under Keel** or **Over Keel** was selected.

Load ship config...

The Load Ship Config command displays the Open dialog box giving access to previously saved ship's configurations. Loading a configuration will result in the replacement of current values in the Draught, Vessel Information, and Sensors Antennas dialog boxes, by new values contained in the loaded file. A ship configuration file as an .shp filename extension.

Save ship config...

The Save Ship Config command displays the Save As dialog box to save the current values contained in the Draught, Vessel Information, and Sensors Antennas dialog boxes under a unique filename. Ship configuration filenames have .shp extensions.

Saved configurations can be retrieved using the Load Ship Config command (see previous paragraph).

8.2.9 Help

The **Help** menu is where the on-line help and information about the current version of the MNS software application can be accessed (see Figure 8-49).
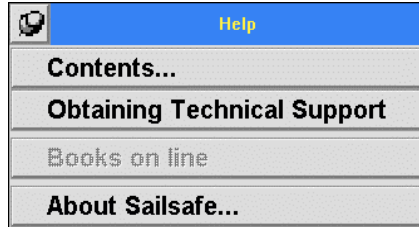
Figure 8-49 - Help Menu

Contents...

The **Contents...** command opens the on-line help window providing detailed information on the MNS and its operation (see Figure 8-50).

Figure 8-50 - Help Window

The **Contents** button brings the first help page back. This is especially useful when a new topic is to be explored.

The **Back** button brings back the previous page viewed by the user.

The **Maximize** button enlarges the Help window so that it will occupy the whole chart viewing area. When this happens, the **Maximize** button is replaced by a **Minimize** button which allows the operator to resize the Help window to its original dimensions.

The **Close** button closes the Help window.

Obtaining technical support

This command displays a dialog box containing the address, phone, and FAX number of Q-MAR (see Figure 8-51).

Figure 8-51 - Technical Support Dialog Box

Books on line

This command provides access to various electronic books as chosen by the operator.

About...

The **About...** command displays the **About Box** dialog box which provides information on the current version and built numbers of the MNS software application and its Viewer module (see Figure 8-52).
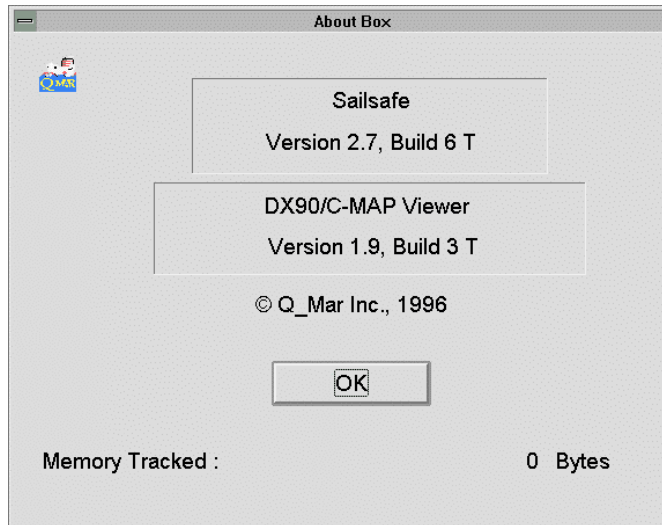
Figure 8-52 - About Dialog Box

8.3 The Toolbar Buttons

The toolbar buttons, on the left-hand side of the main window, provide direct access to some of the most frequently used functions of the MNS. Functions are activated by simply clicking on the appropriate toolbar button.

The following paragraphs provide a detailed description of each toolbar button.

8.3.1 Cancel

The **Cancel** toolbar button performs the same function as the dialog boxes cancel buttons; it cancels the last selection or function activated from toolbar buttons. The functions that can be canceled are: Home, Region, Zoom In/Out, and Zoom Same/New.

8.3.2 Alarm acknowledge

The Alarm Acknowledge toolbar button is a toggle button used to acknowledge alarms generated by the system. Acknowledging alarms will result in the alarm status being updated, and if applicable, in stopping the audible alarms from beeping.

This toolbar button can have four different appearances indicating the status of alarms and the state of the button:

The **NA** state indicates that at least one alarm has not been acknowledged. Clicking on the toolbar button will result in the acknowledgment of all non acknowledged alarms (red status box).

The **ACK** state indicates that all active alarms have been acknowledged, but that at least one alarm condition is still present. Clicking the toolbar button in this state has no effect, except if all alarm conditions have disappeared.

The **OK/NA** state indicates that an alarm condition has been triggered but was gone before it was acknowledged.

The **OK** state indicates that there are no alarm conditions, or that all generated alarms have been acknowledged and that alarm conditions are gone. Clicking the toolbar button in this state has no effect.

8.3.3   Mob

The Man Over Board (**MOB**) toolbar button drops a marker at current ship's position, and creates an entry in the Route window allowing the monitoring of ship's progress relative to the MOB position.

8.3.4   Charts

The **Charts** toolbar button opens the Select Charts window which overlays the chart viewing area and has its own toolbar. See The Select Charts Window paragraph later in this section.

8.3.5   Home ship

The **Home Ship** toolbar button provides single operator action to recenter own ship on the screen in accordance with the setting done with the Home function.

8.3.6 ⇧ ↑ N HDG   North up/Head up

The North Up and Head Up toolbar buttons, positioned side by side, provide the possibility of selecting either a north up or head up (course up when compass data is not available) orientation for chart display.

Note that when the Head Up button is clicked, the chart will be re-oriented in accordance with current heading of the ship. If ship's heading changes significantly, it will be necessary to click the Head Up button again to generate a re-orientation of displayed charts.

8.3.7 [⊠ Region]   Region

The **Region** toolbar button allows the operator to set the screen area within which the ship should be displayed. When this toolbar button is clicked, an orange rectangle will be displayed on the screen. The size and position of that rectangle can be adjusted as desired. During route monitoring in true mode, the ship will automatically recenter to the Home position (see below) when it reaches the now invisible outline of the Region rectangle.

8.3.8 [⊗ Home]   Home

The **Home** toolbar button is used in conjunction with the Region button to set the ship's screen region and homing position. When this toolbar button is clicked, the cursor assumes a "home" symbol and is displayed within the Region rectangle (see Figure 8-53). The "home" symbol can be positioned where desired within this Region rectangle.

During homing position setting, if the cursor is taken outside the outline of the Region rectangle, it symbol changes to a "forbidden" symbol, and clicking will not result in setting the Home position.

Recenter region outline
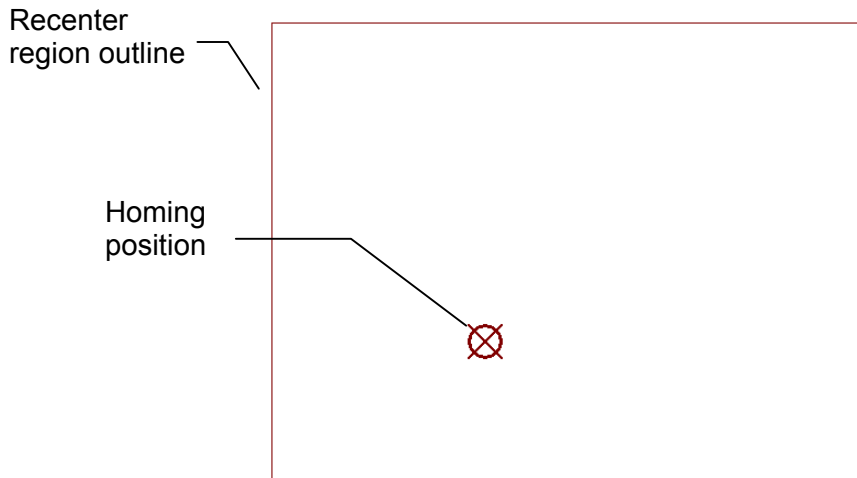
Homing position

Figure 8-53 - Recenter Region and Homing Position

8.3.9 [Zoom All] Zoom all

The **Zoom All** toolbar button displays opened charts at a scale so that the coverage of all charts fits into the chart window. This toolbar button is equivalent to the Fit To Window selection from the Scale button of the Chart window.

8.3.10 [Zoom In] Zoom in/out

The Zoom In/Out toolbar button is a toggle button allowing one to switch between the zoom in and zoom out modes. The toolbar button appearance indicates which zoom function is effective. Switching between the two modes is accomplished by clicking on the toolbar button.

In **Zoom In** mode, the selected chart area, delimited by an orange zoom box, will be enlarged (displayed at a larger scale).

In **Zoom Out** mode, the chart area will be reduced (displayed at a smaller scale) in a proportion equivalent to that of the zoom box over the screen coverage. Note that after a zoom out action, the Zoom In/Out button returns to the Zoom In mode.

8.3.11 Zoom same/new

The Zoom Same/New toolbar button is similar to the Zoom In/Out toolbar button as it is also a toggle button which appearance indicates the active mode.

In **Zoom Same** mode, the result of the zoom function will be displayed within the same chart window, thus changing the scale of the chart.

In **Zoom New** mode, the result of the zoom function will be displayed in a different chart window, thus keeping the original chart display scale in one window, and opening a new chart window for the new display scale. Note that after a zoom new action, the Zoom Same/New button returns to the Zoom Same mode.

8.3.12 Chart (std)

The **Chart** (STD) toolbar button will display the chart(s) contained in the active chart window with standard information when clicked. The standard information level is the one first displayed upon chart window opening. The level of information in the standard level cannot be changed.

This toolbar button is equivalent to the Display Standard Layer command from the Charts menu.

8.3.13 Chart (all)

The **Chart** (ALL) toolbar button will display all the information encoded into the electronic chart(s).

This toolbar button is equivalent to the Display All command from the Charts menu.

8.3.14 Info

The **Info** toolbar button displays the Object Information window which displays identification and attribute values for any point clicked on displayed chart(s) (see Figure 8-54).
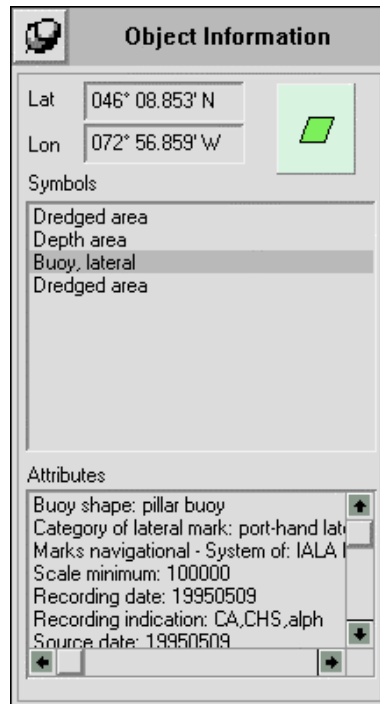
Figure 8-54 - Object Information Window

The **Lat** and **Lon** sections of the window indicate the geographical location of the chart point being interrogated.

The graphical box at the right of the **Lat** and **Lon** sections, shows the appearance of the object highlighted in the Symbols section on the chart. An object in the Symbols section can be highlighted by clicking on it.

The **Symbols** section lists all the chart objects found at the location indicated in the Lat and Long section.

The **Attributes** section gives all the attributes of the object highlighted in the Symbols section.

8.4 The Route Button

The **Route** button, located in the lower left-hand corner of the main window, displays a window which provides information on the route being sailed (see Figure 8-55). When the Route window is opened, this same button closes it.

Route : C:\Sailsafe\routes\Q_MAR\ABC.rte		EDT : 9/4/1996, 15:22			Speed Source : Unknown		
Name	Lat - Lon	CTS	DIST	DTG	TTG	ETA	Speed
Man overboard	045° 34' 37.33" N 073° 30' 24.34" W	191.1°	--	1.75 km	0d+00:04	Tue Apr 09 15:26	13.70 Kts
--	-- --	--	--	--	--	--	--
Quai	045° 34' 19.64" N 073° 30' 45.60" W	--	--	--	--	Tue Apr 09 15:21	13.70 Kts
M173	045° 34' 52.29" N 073° 30' 06.34" W	--	1.32 km	--	--	Tue Apr 09 15:21	13.70 Kts
M171	045° 35' 09.77" N 073° 30' 02.90" W	--	546 m	--	--	Tue Apr 09 15:23	13.70 Kts
M167	045° 35' 53.60" N 073° 30' 14.09" W	349.8°	1.38 km	647 m	0d+00:01	Tue Apr 09 15:23	13.70 Kts
M165	045° 36' 21.47" N 073° 30' 11.72" W	3.4°	863 m	1.51 km	0d+00:03	Tue Apr 09 15:25	13.70 Kts
M161,163	045° 36' 48.26" N 073° 30' 00.37" W	16.6°	864 m	2.37 km	0d+00:05	Tue Apr 09 15:27	13.70 Kts
M157	045° 37' 54.79" N 073° 29' 16.80" W	24.7°	2.26 km	4.64 km	0d+00:10	Tue Apr 09 15:32	13.70 Kts
PAT	045° 39' 01.64" N 073° 28' 31.20" W	25.6°	2.29 km	6.93 km	0d+00:16	Tue Apr 09 15:38	13.70 Kts
M144	045° 39' 55.05" N 073° 27' 42.77" W	32.4°	1.96 km	8.88 km	0d+00:20	Tue Apr 09 15:42	13.70 Kts

Refresh   CIP Section 110   EDT   Speed

Figure 8-55 - Route Window

The title bar of the route window provides the following information:

Route -   the filename of the loaded route being displayed

EDT -   the estimated time of departure for the voyage, if any

Speed Source -   the source of the speed value used to calculate waypoints related data

The Route window contains a list of all the waypoints of the planned route color coded as follows:

Gray -   Past and alternate waypoint
Red -   Current waypoint
Black -   Next waypoints
Magenta -   MOB
in blue box -   Selected waypoint (this waypoint is identified on loaded route by and orange outline)

The following information is provided for all waypoints:

Name -   Name of the waypoint entered as an Object Name attribute during route planning

Lat - Lon - Geographical location of the waypoint

CTS -   Course To Steer from current ship position to reach the waypoint

DIST-   Distance between the previous waypoint and present waypoint
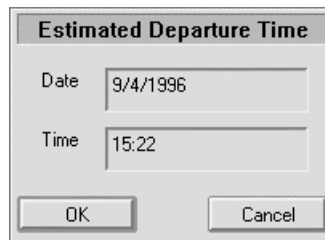
DTG -   Distance To Go to reach the waypoint.

TTG -   Time To Go to the waypoint. The TTG is calculated considering the DTG value and speed value being displayed in the Speed column. The TTG is given in days, hours, and minutes.

ETA -   Estimated Time of Arrival to the waypoint (calculated from either local time or EDT value and TTG).

Speed - The speed value used to calculate the TTG and ETA to waypoints. The speed value displayed is a selection between the following three possibilities from the Speed Source window:

- Actual ship's speed as measured by the GPS (SOG)

- Planned speed as entered as a leg line attribute when route was planned

- Manual speed entered in the Speed Source window and any subsequent changes entered directly into the speed column edit fields

The information displayed in the Route window is not constantly being updated. It is only updated when first opened, when a new waypoint is reached, and when the **Refresh** button is clicked.

To the right of the Refresh button is a text display field which will display the User's Remark attribute of the boxed in waypoint.

The **EDT** button displays the Estimated Departure Time dialog box which allows for the entry of expected voyage start time (see Figure 8-56). When an EDT value is entered and okayed, the system will consider it as the time of departure of the first waypoint of the route, and will calculate all subsequent waypoints time of passage accordingly.

Figure 8-56 - Estimated Departure Time Dialog Box

The **OK** button forces the use by the system of entered estimated departure time value. This EDT will be displayed in the Route window title bar.

The **CANCEL** button forces the use of current time or actual departure time. In this case, the Route window title bar will display a triple-dash (**---**) symbol in the EDT field.

The **Speed** button displays the Speed Source dialog box which allows for the selection of the source of speed data to be displayed in the Route window and used to calculate TTG and ETA values (see Figure 8-57).
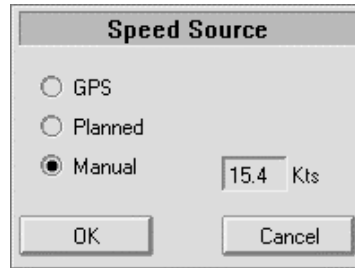
Figure 8-57 - Speed Source Dialog Box

On the right-hand side of the window, there is a scroll bar that allows the operator to scroll through the list of waypoints by clicking on the up or down scroll arrow.

8.5 The Messages Button

The Messages button, located in the lower right-hand side of the main window (see Figure 8-58), displays the Message window which provides information on all alarms generated during the voyage.

Time - Date	Lat - Lon	Messages
Tue Apr 09 19:20:01 1996	045° 34' 33.32" N 073° 30' 29.22" W	No ENC Available :
Tue Apr 09 19:20:18 1996	045° 34' 36.11" N 073° 30' 25.81" W	ENC Available : 79001
Tue Apr 09 19:20:50 1996	045° 34' 41.70" N 073° 30' 19.08" W	Special Condition : Restricted area
Tue Apr 09 19:20:50 1996	045° 34' 41.70" N 073° 30' 19.08" W	Special Condition : Pipeline area
Tue Apr 09 19:20:50 1996	045° 34' 41.70" N 073° 30' 19.08" W	Special Condition : Dredged area
Tue Apr 09 19:20:50 1996	045° 34' 41.70" N 073° 30' 19.08" W	Insufficient Depth : Zone too shallow
Tue Apr 09 19:21:21 1996	045° 34' 47.11" N 073° 30' 12.57" W	Insufficient Depth : Reminder
Tue Apr 09 19:21:22 1996	045° 34' 47.29" N 073° 30' 12.36" W	End of Special Condition : Pipeline area
Tue Apr 09 19:21:22 1996	045° 34' 47.29" N 073° 30' 12.36" W	End of Insufficient Depth : Zone too shallow
Tue Apr 09 19:21:37 1996	045° 34' 49.91" N 073° 30' 09.21" W	Insufficient Depth : Zone too shallow
Tue Apr 09 19:21:53 1996	045° 34' 52.80" N 073° 30' 06.24" W	End of Insufficient Depth : Zone too shallow
Tue Apr 09 19:22:51 1996	045° 35' 05.94" N 073° 30' 03.65" W	End of Special Condition : Restricted area
Tue Apr 09 19:23:09 1996	045° 35' 09.82" N 073° 30' 02.89" W	Insufficient Depth : Zone too shallow
Tue Apr 09 19:23:10 1996	045° 35' 10.04" N 073° 30' 02.95" W	End of Insufficient Depth : Zone too shallow

Figure 8-58 - Message Window

The Message window is divided into three sections providing the following information:

Time - Date -   The local date and time at time of alarm generation

Lat - Lon -   Geographical position of the ship at time of alarm generation

Message -   Type and name of alarm generated.

The last message on the list is the most recent one. If the list gets longer than the window, a scroll bar similar to the one in the Route window will appear and allow the messages to be scrolled through.

8.6 The Status Window

The Status window provides miscellaneous information about the cursor, the ship, the next waypoint, and the alarms (see Figure 8-59). The information in this window is updated every second.

Figure 8-59 - Status Window

The current local date and time is displayed in the **Time** field. The local date and time is derived from the time data provided by the GPS system.

A description of the information provided in the other sections of the Status window is provided below.

8.6.1 The cursor section

The **Cursor** section provides the following information:

Lat: Latitude of current cursor position on the chart. No value is displayed if the cursor is not within a chart window.

Lon: Longitude of current cursor position on the chart. No value is displayed if the cursor is not within a chart window.

Brg: Bearing between a designated point and the cursor. By default, the designated point is the ship. No value is given if the cursor is not within a chart window.

Rng: Distance between a designated point and the cursor. By default, the designated point is the ship. No value is given if the cursor is not within a chart window.

Vrm: Radius of the Variable range marker. No value is displayed if the Cursor VRM tool is not ON.

8.6.2 The ship section

The **Ship** section provides the following information:

Lat: Latitude of current ship position. This information is not related to chart windows i.e. the information is available even if no chart windows are opened.

Lon: Longitude of current ship position. This information is not related to chart windows i.e. the information is available even if no chart windows are opened.

RoT: The rate of turn of the ship based on either heading data received from the gyro compass, or COG data received from the GPS. The rate of turn is given in degrees per minutes, and a prefix indicates if the change is to Port (Port) or starboard (SB).

Hdg: Ship's heading as read from the gyro compass. This information is only available if an interface to the gyro compass is provided.

COG: Ship's Course Over Ground as read from the GPS receiver. The COG is the direction of movement of the conning position.

SOG: Ship's Speed Over Ground as read from the GPS receiver.

B.Brg: The Beam Bearing length. This information is only displayed when the Beam Bearing tool is turned ON.

R.Rng: The radius of the Range Ring. This information is only displayed when the Range Ring tool is turned ON.

8.6.3 The waypoint section

XTD: Ship's cross-track distance from the planned route. The cross-track distance is calculated as a perpendicular between the planned route and the ship. A suffix indicates on which side of the planned route the ship is; Port means that the ship is to the left (Port) of the route (route is on ship's starboard side), and a SB means that the ship is to the right (Starboard) of the route (route is on ship's port side). Note that in order for the system to calculate a cross-track distance, it is necessary to have a planned route loaded and a current leg line selected.

CTS: The Course To Steer to reach the next waypoint. This value is the same as the one indicated in the route window for the waypoint displayed in red, except that it is updated every second.

DTG: The Distance To Go to reach the next waypoint. This value is the same as the one indicated in the route window for the waypoint displayed in red, except that it is updated every second.

8.6.4 The alarms section

The **Alarms** section of the Status window provides the status of each individual alarm that can be triggered. This status is provided through a color coded box located to the immediate left of the alarm name. The color scheme is as follows:

Gray: No alarm condition exists.
Red: An alarm has been generated, and has not been acknowledged yet.
Green: An alarm has been generated and acknowledged, but the alarm condition still exist.
Yellow: An alarm has been generated, but the alarm condition was gone before alarm acknowledgment.

The various alarms are grouped into two different sub-sections (described in the following paragraphs). It is possible to view more information about any generated alarm by clicking on its alarm box. This action will display a window equivalent to the Messages window containing a tabulation of all occurrences of the alarm. The window can be closed by clicking again on the alarm box.

Navigation alarms
The navigation alarms include the following alarm types:

Insufficient Depth: Generated when the safety region crosses an area where water depth is shallower than the deep water contour.

Cross Track Error: Generated when the smallest distance between the ship and the planned route exceeds the value of the cross track extent entered as a route leg line attribute (see paragraph 0).

Special Condition: Generated when the safety region crosses one of the following types of area:
Traffic separation zone
Traffic routing scheme crossing or roundabout
Traffic routing scheme precautionary area
Two-way traffic route
Deepwater route
Recommended traffic lane
Inshore traffic zone
Fairway
Restricted area
Caution area
Offshore production area
Areas to be avoided
Military practice area
Seaplane landing area
Submarine transit lane
Ice area
Channel
Fishing ground
Fishing prohibited
Pipeline area
Cable area
Anchorage area
Anchorage prohibited
Dumping ground
Spoil ground
Dredged area
Cargo transhipment area
Incineration area
Specially protected areas

Anchor Zone: Generated when the ship leaves the safety of the anchor zone set using the Draw Anchor Zones command of the Markers menu (see paragraph 0)

Chart Not Available: Generated when the next chart to be sailed is not available in system's memory, or is not in the proper chart directory.

Depth Offset: Indicates the value of the manual or automatic depth offset applied to the chart.

Positioning data
The positioning data alarm group consists of the following alarm types:

Main GPS Failure: Generated when the GPS data is not valid, or when no fix is available.

There are three parameters being constantly displayed to monitor the accuracy of the GPS position solution:
- HDOP: Horizontal Dilution Of Precision which gives an idea of the relative precision of horizontal positioning
- Sats: Indicates the number of satellites being tracked of the number of visible satellites
- Mode: Indicates the current operating mode of the GPS receiver. The possible modes are:
3D DGPS: corrected solution along the horizontal and vertical axis (<10m accuracy)
3D: solution along the horizontal and vertical axis (<100m accuracy)
2D: solution in horizontal axis only (<100m accuracy)
Unknown: data not received or transmitted from the GPS receiver
DR: Dead Reckoning mode is On
DR Stop: Dead Reckoning mode On but stopped
Loran-C: Loran-C (back-up) data being used for ship's positioning (when connection is provided)

Beacon Failure: Generated when the GPS does not report the application of differential corrections to the positioning solution.

There are two parameters being constantly displayed for monitoring:
Beac Freq: The frequency of tuned beacon station
Beac Str: The strength of the beacon signal in dB μV/m

8.7 The Select Charts Window

The Select Charts window opens when the Charts toolbar button is clicked, and occupies the whole chart viewing area (see Figure 8-60). It also has its own toolbar which slightly differs from the main window one.

The Select Charts window displays a chart of the world, and identifies by a red outline the electronic nautical charts available in the selected directory. This world map can be enlarged for better identification and selection of chart(s) to be loaded, or reduced to have a better appreciation of available chart coverage.
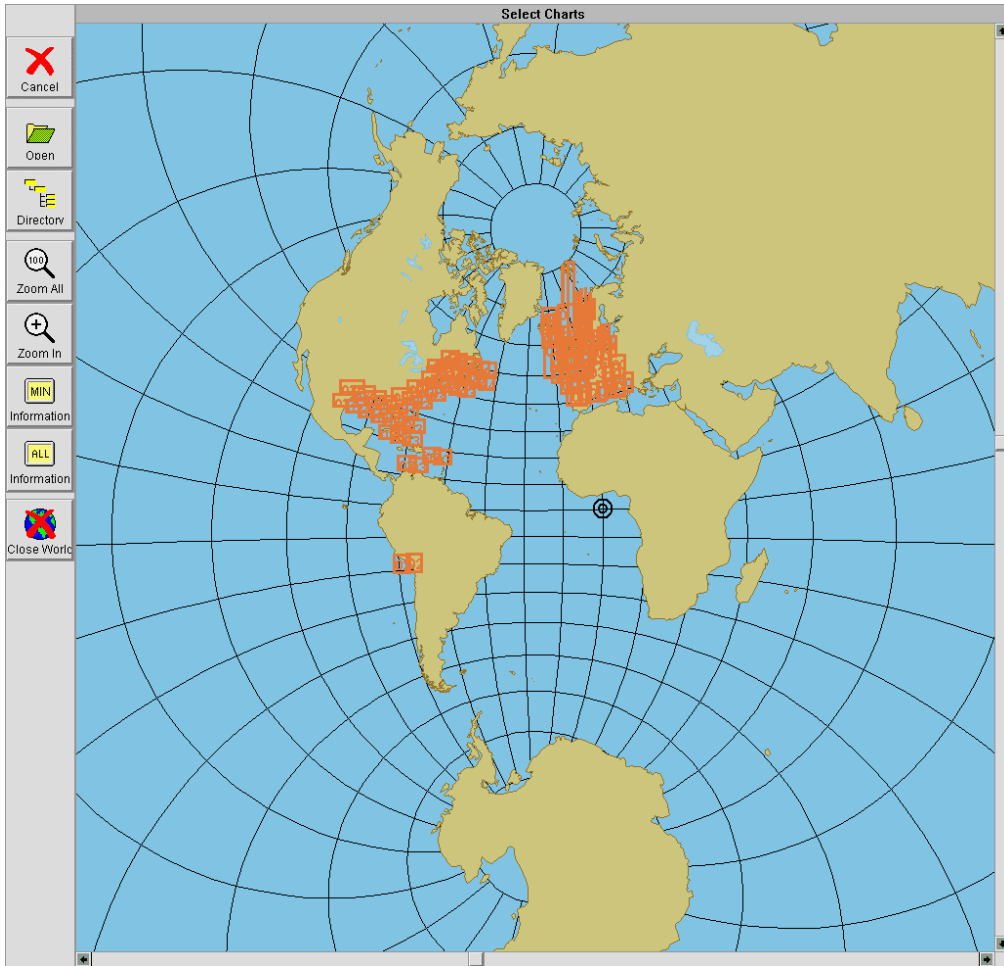
Figure 8-60 - Select Charts Window

The Select Charts window also includes horizontal and vertical scroll bars that allow to move around the world without changing scale.

8.7.1 Toolbar buttons

The toolbar buttons, on the left-hand side of the Select Charts window, provide direct access to all of the available functions of that window. Functions are activated by simply clicking on the appropriate toolbar button.

The following paragraphs provide a detailed description of each toolbar button.

Cancel

The **Cancel** toolbar button performs the same function as in the main window. In the Select Charts window context, it allows to exit the zoom mode without executing it.

Open

The **Open** toolbar button loads the electronic chart(s) selected from the world map. Selected charts are shown with a black outline. When a chart is loaded from the Select Charts window, the window is automatically closed and replaced by the Main window.

Directory

The **Directory** toolbar button displays the Choose Directory dialog box (see Figure 8-61). This dialog box allows the operator to select the directory which contents is to be displayed on the world map. Of course, selected directory must contain proper chart dictionary file to display corresponding chart outlines.
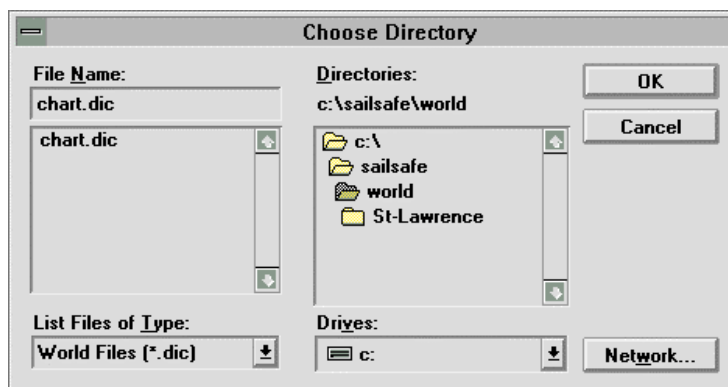
Figure 8-61 - Choose Directory Dialog Box

Zoom all

The **Zoom All** toolbar button displays the world map at full extent (whole world visible within the Select Charts window).

 Zoom in/out

The Zoom in toolbar button is a toggle button allowing to switch between the zoom in and zoom out modes. It operates exactly as in the Main window. The toolbar button appearance indicates which zoom function is effective. Switching between the two modes is accomplished by clicking on the toolbar button.

 In **Zoom In** mode, the selected chart area, delimited by an orange zoom box, will be enlarged (displayed at a larger scale).

 In **Zoom Out** mode, the chart area will be reduced (displayed at a smaller scale) in a proportion equivalent to that of the zoom box over the screen coverage.   Note that after a zoom in action, the mode returns to Zoom In.

 Information (MIN)

The **Information (MIN)** toolbar button displays the world map with the lowest level of details (i.e. no undersampling).

 Information (all)

The **Information (ALL)** button performs an undersampling of the charts outlined on the world map to show partial chart geographic data. This feature greatly facilitates chart identification and exact coverage.

 Close world

The **Close World** button closes the Select Charts window and returns the control to the main window.

8.8 The Chart Window

The Chart window contains the chart(s) on display. One is created automatically when either a new chart is loaded from the Select Charts window, or a Zoom New action is performed. Up to sixteen (16) chart windows can be simultaneously opened in the chart viewing area of the Main window. The active Chart window, to which chart viewing functions apply, can be identified by its blue background title bar. The following paragraphs address the particularities of chart display within the Chart window, and the functions available from the title bar buttons.
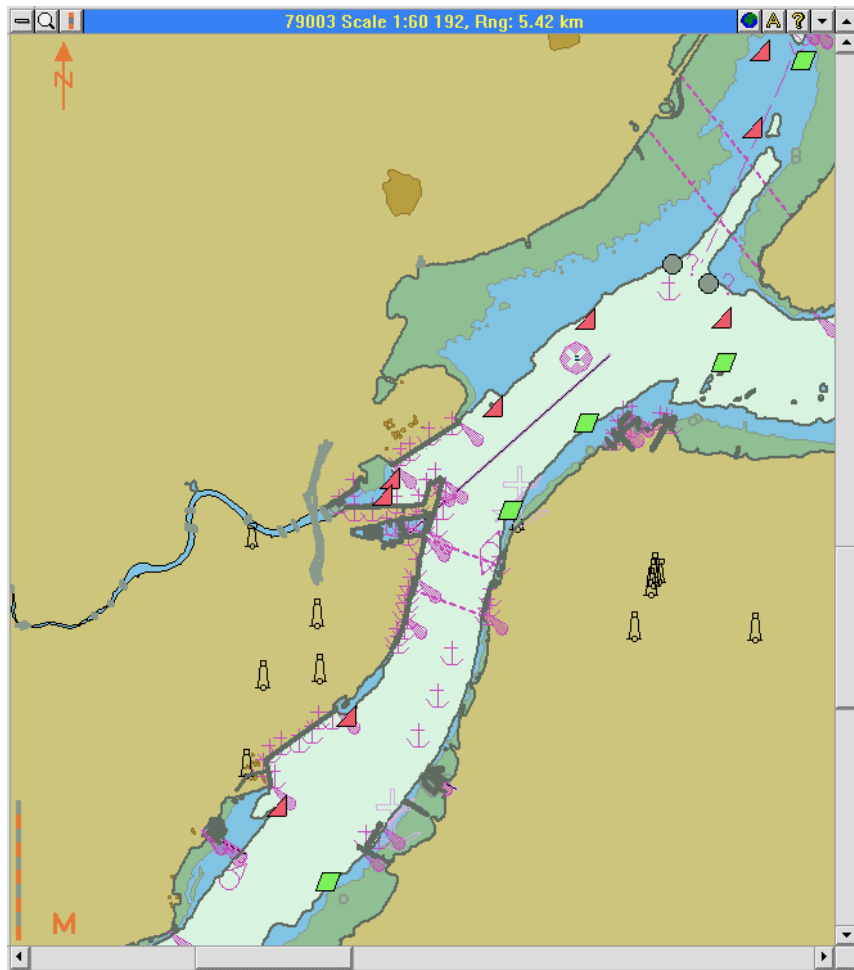
Figure 8-62 - Chart Window

8.8.1 Chart display

The display of any electronic nautical chart, regardless of its format, is done through a Chart window. Each Chart window provides a seamless world environment permitting loading and displaying up to sixteen (16) charts simultaneously.

Each Chart window has its own title bar which indicates the number of the current electronic chart, its viewing scale and range, and each bar contains a set of buttons.

Horizontal and vertical scroll bars allow panning of the chart without changing viewing scale.

Loaded charts
When a new Chart window is created, it displays its content at a scale which allows to view full loaded chart(s) coverage. In the seamless world environment provided by the MNS, overlapping sections are always displayed with the best scale chart on top.

With multiple charts loaded in the same Chart window, a "current" chart is designated. The current chart is the one which number appears in the Chart window title bar. Note that the current chart is not necessarily the chart being viewed in the Chart window. In fact, the current chart may even be totally outside the Chart window display. When own ship position is available, the current chart is the chart where the ship is located.

Overlaid to the loaded chart(s) on the left-hand side from top to bottom (see Figure 8-62), are the following indicators:

North: Indicating the north direction relative to the chart.

Scale Bar: Providing an approximation of distances on the chart. The scale bar can take one of two appearances; at scales smaller than 1:80 000 it is a 10nmi long bar with markings every 2nmi, at scales larger than 1:80 000 it is 1nmi long composed of alternating red and gray 0.1nmi long sections.

Metric: Indicating that the data encoded in the electronic chart is in meters. The "M" indicator is of course not displayed if the original chart data was encoded in a different unit of measure.

The Chart window title bar provides another useful indication to be considered when viewing charts: the overscale condition. If the viewing scale exceeds by a factor of two or more the current chart compilation scale, an Overscale indication will appear between the chart number and viewing scale with the amount of overscale indicated in parenthesis (see Figure 8-63).

Figure 8-63 - Overscale Indication

Unloaded charts
In a fashion similar to what is found for the Select Charts window, the outline of unloaded but available charts is shown in yellow in the Chart window (see Figure 8-64). The extent of the unloaded chart outline shown depends on the scrolling provided by loaded charts. The scroll limitation is that the Chart window must always display, at least partially, a loaded chart.
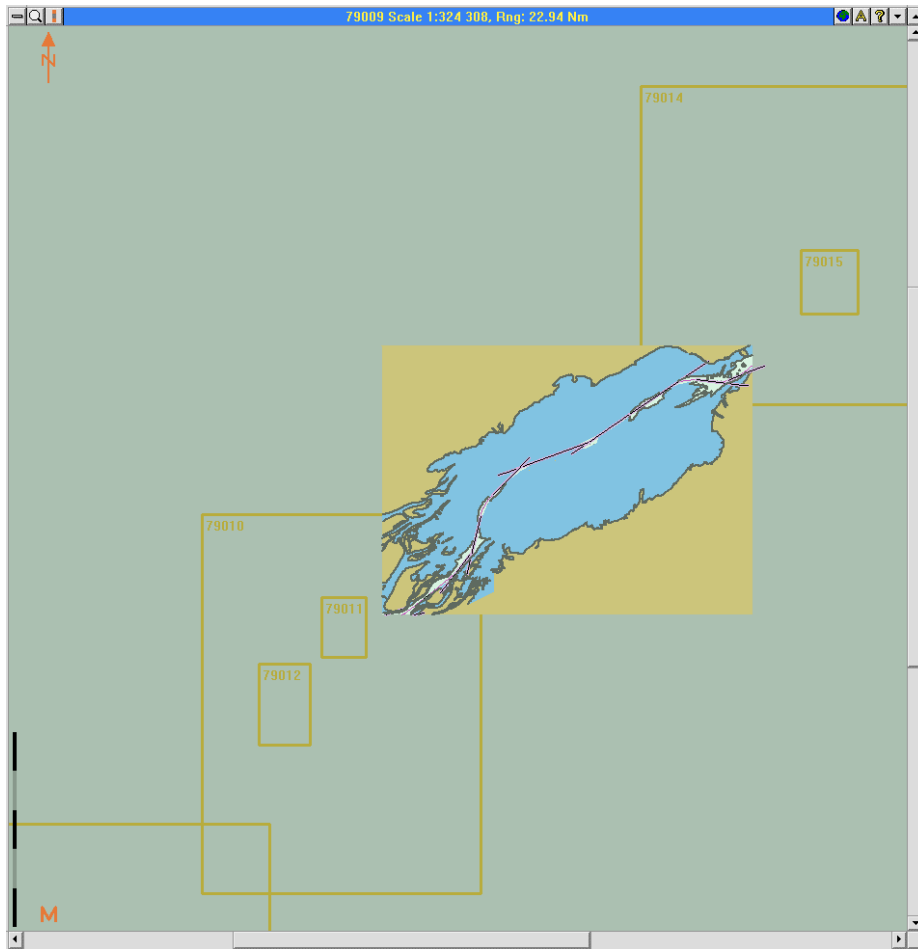
Figure 8-64 - Chart Window Displaying Unloaded Charts

8.8.2 Title bar buttons

The Chart window title bar contains eight buttons as described in the following paragraphs.

 Control menu

The Control Menu button is a standard window buttons which displays the following options:

Restore: This option restores the Chart window to the size and location defined prior to
            the minimize action. Of course this option is active only when the Chart window
            is minimized.

Minimize: This option reduces the Chart window to an icon with chart number and viewing scale identified. This option is equivalent to the Minimize title bar button.

Maximize: This option resizes the Chart window to the full main window chart viewing area. This option is equivalent to the Minimize title bar button.

Close: This option closes the Chart window.

Q *Scale*
The Scale button displays a list of viewing scales that can be selected for the active Chart window. The **Fit to window** selection will automatically selected a viewing scale that will display the whole opened charts coverage within the Chart window.

Note that when a ship is displayed in the Chart window (i.e. the ship symbol is visible), chart(s) rescaling will be centered on the ship. When no ship is displayed in the Chart window, chart(s) rescaling will be centered on the Chart window center point.

▪ *Range*
The Range button displays a list of viewing ranges that can be selected for the active chart window. The range selected is applied as a radius around the ship or the Chart window center point depending if a ship symbol is visible on the Chart window current viewing scale or not.

◉ *Charts*
The Charts button provides information on loaded and unloaded charts as follows:

- Loaded charts are listed first with the current chart grayed out.

- Unloaded charts which have coverage in the Chart window current viewing scale are listed below a separation line.

Clicking on a chart number from the first group (loaded charts) will make this chart the active one.

Clicking on a chart number from the second group (unloaded charts) will result in the loading and display of that chart.

A *Automatic / manual loading*
This button acts like a toggle for the selection of the chart loading mode.

    A   When in Automatic mode, the next chart to be sailed on by the ship will automatically be loaded onto the same Chart window

| M | When in Manual mode, charts must be selected and loaded manually. |

? *Chart info*

The Chart Info button displays information encoded in the current chart header file.

This typically includes:
- Chart number
- Comments
- Compilation date
- Compilation scale
- Depth units
- Height units
- Horizontal datum
- Vertical datum
- Sounding datum

▼ *Minimize*

The Minimize button performs the same action as the Minimize option from the Control Menu button; it reduces the Chart window to an icon in the lower left-hand corner of the Main window.

▲ *Maximize*

The Maximize button performs the same action as the Maximize option from the Control Menu button; it resizes the Chart window to occupy the full Main window.

8.9 Other Windows

8.9.1 The ARPA target window

The ARPA Target window displays information received from the Automatic Radar Plotting Aid (ARPA) module of the onboard radar. Available information is as follows:

Title bar: Target designation or name
Rel.Brg: Bearing of the ARPA target relative to ownship
Rng: Distance between the target and ownship
COG: Course Over Ground of the target (true)
SOG: Speed Over Ground of the target (true)
CPA Rng: Shortest distance to be reached between the target and ownship considering current their current course and speed
TTCPA: Time remaining (in minutes and seconds) before the CPA point is reached (a "0" or negative value indicates that the CPA point has been passed)

Bow X: Distance between the target and ownship when the target crosses the heading line of ownship (a null field indicates that the target will not cross ownship heading line)

TTBX: Time remaining (in minutes and seconds) before the Box X point is reached (again, a null field indicates that the target will not cross ownship heading line)

The ARPA Target window opens upon clicking on the ARPA target.

Arpa #1	
Rel.Brg:	76.5°
Rng:	227 m
COG:	335.0°
SOG:	25.0 km/h
CPA Rng:	100 m
TTCPA:	00:50
Bow X:	317 m
TTBX:	01:15

Figure 8-65 - ARPA Target Window

8.9.2 The AIS target window

The AIS target window displays information on a particular target picked up by the Automatic Identification System. The format of this window, and the information it provides, is identical to that of the ARPA Target window. An interface to the onboard AIS system must be available to obtain this information. This window opens upon clicking on the AIS target.

CCG03	
Rel.Brg:	246.8°
Rng:	2.47 km
COG:	47.8°
SOG:	14.5 km/h
CPA Rng:	270 m
TTCPA:	06:14
Bow X:	627 m
TTBX:	04:47

Figure 8-66 - AIS Target Window

9. HARDWARE PRODUCTS

9.1 Ship-based Configuration

Based on the design philosophy established at the very beginning of the MNS project, the hardware design was to favor the use of off-the-shelf components as much as possible. The advantages of this approach included: flexibility in component selection, availability of replacement parts, numerous sources of supply, ease of system upgrade upon availability of better hardware.

The design focus for the ship-based system hardware was the capability to support system functions, and provide optimum performance.

9.1.1 Computer

From the usage of the MNS prototype, it was determined that in order to obtain acceptable performance from the system, it was necessary for the main computer to be pentium microprocessor based. It was also determined that due to the number of electronic charts that can be opened and their sizes, 32MB of on-board Random Access Memory (RAM) is required to avoid constantly reading on the hard disk and slowing down the system. This quantity of RAM also ensures at least standard performance for the operating system. The required size of hard disk memory is really dependent on the number of charts to be stored on it. It was estimated that considering the number and size of electronic charts presently available on the market, a 540MB hard disk would a minimum, but that 1GB would be preferable.

The computer would be of open architecture type allowing for the installation of high performance video cards, audio cards, serial interface cards, and local area networking cards.

The video card would support at minimum 256 colors at 1 280 x 1 024 pixels resolution.

The serial interface card would support a minimum of 8 peripherals.

The local area networking card would support ethernet links.

The Hewlett-Packard Vectra (XU) computer system was found to be the only PC to be "type approved" for use as a "loading instrument" in marine application by classification societies such as Bureau Veritas, DNV, Korean Register… In addition to a high performance Pentium Pro™ processor, it includes a high definition 21" display monitor, and a "mariner kit" that allows the mounting of these components on shock-mounts for a certified installation.

9.1.2 GPS and beacon receivers

The GPS and Beacon receivers, and their antennas, formed the basis of the ship-based system positioning system. Although space and weight were not of primary importance for the ship-based system, it was still preferable, for consistency and ease of integration, to select the same receivers and antennas as for the pilot system. The preferred GPS receiver therefore had to be a combined type where the GPS and Beacon receivers are housed within the same enclosure, and the same for the antennas; a combined GPS and Beacon antenna.

Initial trials were conducted with a Magnavox MX4200/MX50R combination with split antennas. Northstar's 8900 model offering a compact "black-box" type combined receiver was also used during trials. Both gave excellent results; which highlights the MNS' flexibility to interface to different types of GPS.

9.1.3 RF communications

MNS to MNS and MNS to shore communications was to be implemented through the Automatic Identification System (AIS). Two types of transponder were identified for potential utilization; Ross Engineering's DSC 12500, and Swedish Space Corporation's GP&C. It was planned that the ship-based system would be able to communicate and acquire information from either transponder.

9.1.4 Console mounting

The integration of the various components had to result in a very functional workstation with consideration for ergonomic and esthetic factors. The design of a console based on standard off-the-shelf items was attempted, but yield an unsatisfactory result (see Figure 9-1).

From that experience, and from user's feedback, it was established that the console had to offer the possibility of mounting standard 19" rack-mountable hardware (such as a UPS), and be equipped with slides to facilitate maintenance, that the display monitor mounting would be such that the viewing angle would be comfortable for the operator, and that the keyboard would be of the "backlit" type for night operation. It was also found during trials that operators prefer full-travel keyboard keys to membrane keyboards.

Figure 9-1- MNS Off-the-shelf Console

The design of a console unique to the MNS was awarded to the industrial designer firm.

The design featured a pivoting turret (display monitor, keyboard, and trackball), and slide mounted drawers for easy installation and maintenance of all components. The full console is mounted on shock mounts to withstand the harsh shipboard environment. Figure 9-2 shows a picture of the console.

Figure 9-2 - MNS Ship-based Console

Components which were selected for incorporation into the console (and the MNS) include:

Table 9-1 - Ship-based Configuration Components

Component	Manufacturer	Remarks
Computer	Hewlett-Packard	Vectra XU - 180MHz Pentium Pro processor - 32MB RAM - 1GB Hard Disk Drive - CD-ROM
Monitor	Hewlett-Packard	Model D2800 - 21" - 1 600x1 200 resolution
Mounting kit	Hewlett-Packard	Type approves H-P products as loading equipment in marine applications
Keyboard and trackball	Cortron Evergreen	- 101 keys - backlit
GPS/DGPS receiver	Northstar	Model 8900 - combined receivers and antennas
Gyro interface	Consolidated Tech	
	Alliance Nav	- includes heading display
Serial interface	Digiboard	- 4 or 8 ports available
Uninterruptible power supply	APC	- 1 000VA - rack mounted

The interconnection of these components is shown in Figure 9-3.
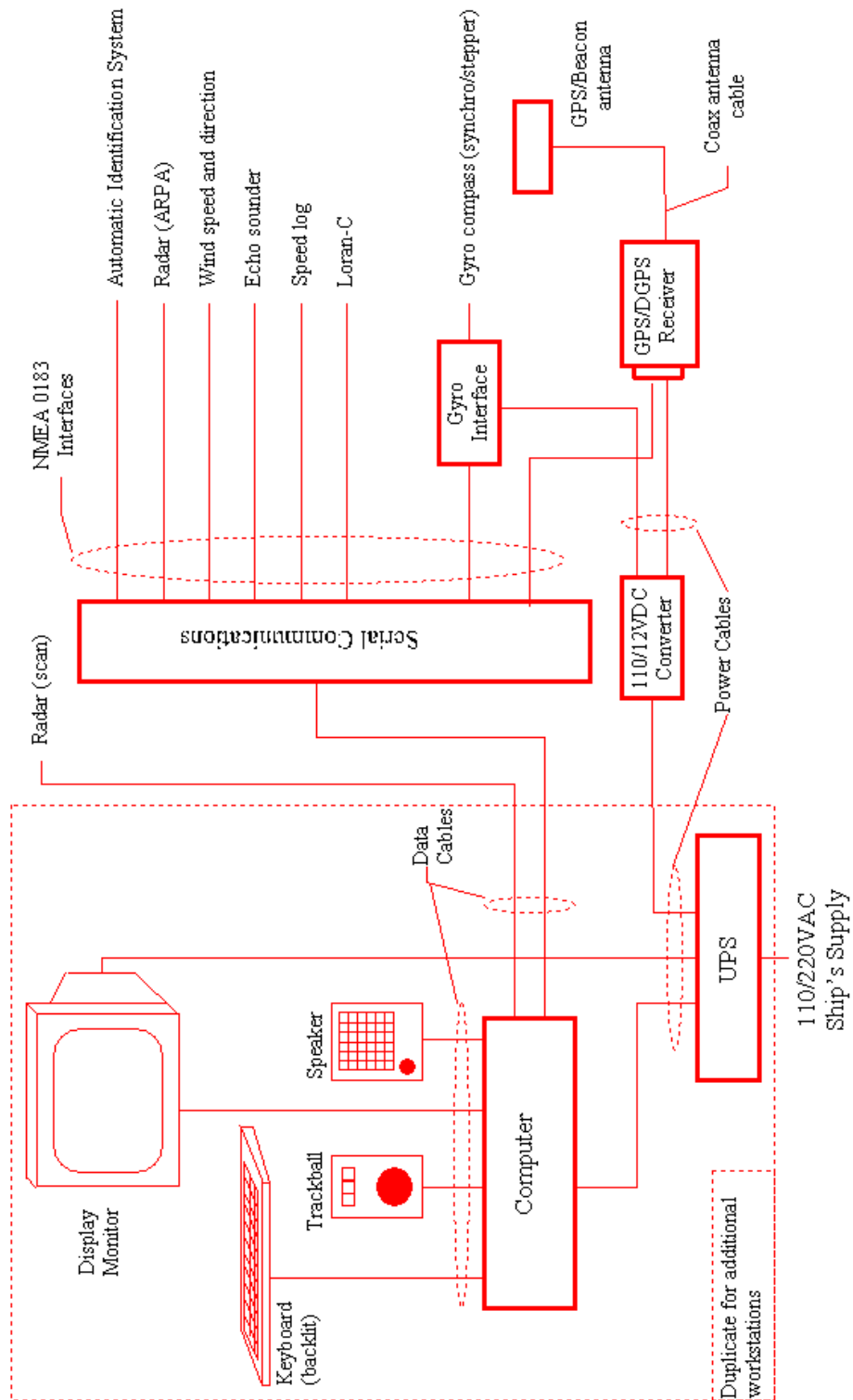
Figure 9-3 - Ship-based Version Interconnect Diagram

9.2 Pilot Configuration

The hardware aspect of the pilot system was crucial in the overall design. In fact, it was the hardware that set the achievable size and weight limits. The hardware also had to support the functionality provided by the software to ensure an adequate overall system performance.

9.2.1 Computer

The computer to be used for the pilot system had of course to be portable. To ensure performances similar to that of the ship-based version, the Pilot version had to offer a computer with similar characteristics.

The computer display had to have the highest possible resolution and size. At the time it meant 12.1" at a resolution of 600 x 800 pixels (the evaluation of 480 x 640 resolution display revealed that image precision was not acceptable, and that display "real-estate" was insufficient to support the MNS user interface).

At least one serial communication port (RS-232C) had to be available on the portable computer for communication with the positioning system. The pointing device also had to be easy to use and control under unstable conditions (thus eliminating the small trackball often found on portable models),

All trials were performed on a IBM Thinkpad 360C (see Figure 5-3).

9.2.2 GPS and beacon receivers

As previously mentioned, this component of the Pilot version would be the same as for the Ship-based version. Because of its reduced size and weight, the Northstar model 8900 was selected for the Pilot hardware design.

9.2.3 RF communications

The Pilot version had to be capable of supporting the same type of RF communications as the Ship-based version. This is specially important for the Pilot version as the AIS would become the major source of data for collision avoidance monitoring (a radar interface would not be available).

9.2.4 Antenna group

The original concept of the antenna group, which involved radio modem communication between the portable computer and the GPS/DGPS receiver, raised some serious concerns. Under this concept, the antenna group, housing the GPS/DGPS receiver, a radio modem,

and a battery, would be mounted outdoors and be exposed to the weather. Concerns raised included:

- powering of the GPS/DGPS receivers and the radio modem (they require 12 to 30VDC)
- operating temperature of the GPS/DGPS receivers (most have a lower limit of 0°C)
- battery efficiency at very low temperatures
- required autonomy (Les Escoumins-Montreal ≈16 hrs)
- reliability of the radio link (had to be as reliable as a coax cable)

Possible solutions to these problems were explored with several GPS and antenna specialists including Canadian Marconi Co., Antenna Research inc., and Telson Communications inc.. Other approaches, like an inductive link between the GPS/DGPS antenna and the receiver, were also investigated. Unfortunately, no practical solution could be designed within the established size, weight, reliability, autonomy and performance requirements.

9.2.5 Briefcase

The design of a rugged briefcase-type enclosure of the pilot system was subcontracted to a firm specialized in this type of design (see Figure 9-4).

The design features a watertight briefcase, portable computer mounting cradle, a universal power supply, a battery pack for the GPS/DGPS receiver, and accessible connectors for antenna and AIS interfacing.

Figure 9-4 - MNS Pilot Briefcase

Components which were selected for incorporation into the Pilot system include:

Table 9-2 - Pilot Configuration Components

Component	Manufacturer	Remarks
Computer	OceanPC	Intrepid 6000I - 133MHz Pentium processor - 32MB RAM - 1GB Hard Disk Drive - CD-ROM - Corrosion, moisture, shock and vibration protection
GPS/DGPS receiver	Northstar	Model 8900 - combined receivers and antennas

10. FINAL TEST RESULTS

Ship-based and pilot system configurations were both subjected to thorough testing of all their features, functions, and options. Prototypes of both configurations were installed on board the CCG sounding vessel F.C.G. Smith, where the extensive functional and operational tests were conducted. Witnessing these tests were representatives from Q-MAR Inc., the Transportation Development Centre, and the Canadian Coast Guard. The test results for the ship-based and pilot configurations can be found in Appendices D and E respectively.

10.1 Ship-based Configuration

Only two items were noted during the development tests. These items are repeated below with an analysis.

1- *In step 113 of the test, the Object Name attribute was not retained by the first waypoint*

The Object Name attribute, and all other non-default attributes, are applied to the highlighted waypoint or legline when entered. Step 109 of the procedure called for the entry of the Object Name attribute <u>before</u> the first waypoint was created and highlighted. This procedural error caused the Object Name attribute not to be retained for the first waypoint.

2- *In step 129 of the test, 3 depth zones are displayed when "2 Depth Zones" is selected (that's including the intertidal zone).*

The definitions and nomenclature dictated by IMO/IHO were strictly followed for the identification and naming of the depth zones. The inconsistency resides within the S-52 IHO specification.

The operational tests were completed successfully.

10.2 Pilot Configuration

Only three items were noted during the development tests. These items are repeated below with an explanation.

1- *In step 14 of the test, a File Corruption message was displayed upon loading of CHS chart 79021*

Further verification at Q-MAR's offices revealed that certain copies of chart 79021 are indeed corrupted.

2- *In step 113 of the test, the Object Name attribute was not retained by the first waypoint*

> The Object Name attribute, and all other non-default attributes, are applied to the highlighted waypoint or legline when entered. Step 109 of the procedure called for the entry of the Object Name attribute <u>before</u> the first waypoint was created and highlighted. This procedural error caused the Object Name attribute not to be retained for the first waypoint.

3- *In step 129 of the test, 3 depth zones are displayed when "2 Depth Zones" is selected (that's including the intertidal zone).*

The definitions and nomenclature dictated by IMO/IHO were strictly followed for the identification and naming of the depth zones. The inconsistency resides within the S-52 IHO specification.

Operational tests were completed successfully.

11. CONCLUSIONS

The successful completion of the development and operational tests for both the ship-based and pilot system configurations of the MNS, demonstrated that the functional objectives of the development were met. The only initial design element that was not fully resolved was the wireless link between the portable system and its GPS/DGPS receiver. This element represents a great challenge considering the conditions and environment under which it would have to operate. It is worth reiterating that reliability is the key factor for any potential solution to this problem.

The exposure of the MNS technology through merchant marine and Coast Guard vessels, generated a lot of interest in the marine community. Although certain groups may seem hesitant in endorsing this technology, we can nevertheless safely affirm that there is a definite recognition of the benefits in using the MNS. This was particularly evident when MNS equipped vessels set a precedent in sailing the St. Lawrence River during winter nights on a regular basis. The level of confidence of users towards the MNS has rapidly risen. We predict that in today's context of Canadian Coast Guard cost recovery program, shipowners' tight operating margins, east coast port competition, and environmental safety issues, the MNS technology will very soon be indispensable to minimize transit time on the St. Lawrence River in a safer than ever manner.

12. RECOMMENDATIONS

To overcome limitations of the MNS and to augment its capabilities in terms of displayed information precision, it is recommended that the integration of the following emerging technologies be investigated:

- Predictive maneuvering (developed by CORETEC Inc.)
- River bottom modeling (based on HYDROSTAT technology)

In addition, with the increasing availability of dynamic navigational data in a real-time manner, it is recommended that development of the MNS be pursued to turn it into a major Navigational Information Integration Centre (NIIC), presenting complete navigational data in a comprehensive graphical manner to the mariner.

It is recommended that the first steps to convert the MNS into a NIIC be the following:

- Design and test the integration and display of ice information
- Investigate the integration of real-time and predicted current data using IMO/IHO compliant symbology
- Study the feasibility of weather data acquisition and display

Appendix A

MNS System Specifications

Appendix A

MNS System Specifications

This system specification identifies the functional requirements to be met for the design and development of the Maritime Navigation System (MNS). The specification is written to cover all possible requirements regardless of system configuration. To determine the applicability of a requirement to a specific configuration of the MNS, refer to table 5 of paragraph 5.3.7.5.

Note: This specification was prepared based on the results of phase 1 feasibility study and is therefore subject to revision upon completion of phase 4 of the project.

1. Applicable specifications

The following documents are deemed to form an integral part of this specification. In case of conflict between this specification an any reference document, this specification shall take precedence.

Maritime Safety Committee MSC/Circ.637 27 May 1994	Performance standard for Electronic Chart Display and Information System (ECDIS)
International Hydrographic Organization Special Publication No.52	Provisional Specifications for Chart Content and Display of ECDIS
International Hydrographic Organization Special Publication No. 57	IHO Transfer Standard for Digital Hydrographic Data

2. System Inputs

2.1 Chart
The Maritime Navigation System (MNS) shall accept electronic navigational charts in the vector format as supplied by the Canadian Hydrographic Service, and in raster data format.

These electronic charts shall be electronic representations of the paper maps supplied by the Canadian Hydrographic Service, displayed in full color on color systems.

2.1.1 Vector
The MNS shall support the International Hydrographic Organization (IHO) DX90 vector chart file formats.

Interrogation of chart elements (buoy, lights, depth contours ...) shall be possible.

2.1.2 Raster
The MNS shall be capable of displaying charts available from the Admiralty Raster Chart Service (ARCS).

2.2 Positioning System

GPS signals shall be used as primary source of positioning by the MNS. The MNS shall also receive and process DGPS differential correction signals transmitted
in accordance with data format and communication protocol RTCM-104 v.2.x. Broadcast standard from the US Coast Guard.

The MNS shall not degrade the positioning accuracy provided by the main positioning system.

The following information shall be available over the interface from the positioning system (unit of origin will depend on receivers type, model, and configuration):

a. geographical position (latitude, longitude)
b. Speed Over Ground (SOG)
c. Course Over Ground (COG)
d. Universal Time Coordinated (UTC)
e. date
f. number of satellites being tracked
g. GPS operating mode
h. Horizontal Dilution of Precision (HDOP) data
i. correction signal source station
j. loss of DGPS correction signal

2.3 Radar

The requirements for a radar interface shall be the subject of a separate study.

2.4 COWLIS

The MNS shall be capable of communicating with the Coastal Ocean Water Level Information System (COWLIS), and acquire real-time water level readings through an RF link (data format and communication protocol to be determined).

2.5 Serial Interfaces

The Ship-Based MNS shall have a minimum of eight (8) RS-232/422 compatible interfaces for connection with shipboard instruments. MNS serial communications shall conform to

NMEA 0183 sentences. The MNS shall provide interface capability to the following shipboard instruments and sensors:

    a. depth sounder
    b. draught indicator
    c. electronic speed and log
    d. electronic gyro compass
    e. flux gate compass
    f. Loran-C
    g. SATellite NAVigation system (Satnav)
    h. anemometers
    i. wind Direction

2.6 User

The MNS shall provide a comprehensive User Interface (UI) for the selection of display options and the entry of information. The UI shall support all options described herein and shall consist of, but not be limited to, the following:

    a. display options: 1. units of measure
        2. vessel homing position
        3. chart reset
        4. compass rose
        5. range rings
        6. search And Rescue (SAR) grid
        7. latitude/Longitude grid
        8. radar overlay
        9. help menus
        10. color palette

    b. information entry: 1. position offset
                               2. vessel draught
                               3. voyage time constraints (departure/arrival)
                               4. modification of route
                               5. acceptance/rejection of route
                               6. static position condition
                               7. time/distance to next waypoint threshold
                               8. cross-track error threshold
                               9. lat/long alarm time threshold
                               10. gyro update alarm time threshold
                               11. watch alert time threshold

12. position corrections
13. event mark button
14. self test
15. rate of voyage track sampling
16. manual target (target course and speed)
17. trial maneuvering (vessel position, course, and speed)
18. UTC time
19. local time offset

2.7 RF Communications

The MNS shall provide a Radio Frequency (RF) link to communicate with other MNS equipped vessels and ground stations (data format and communication protocol to be determined).

2.8 Other Inputs

The MNS shall provide an access method to electronic databases. The information contained in these electronic databases shall be retrievable.

3. Outputs & Displays

3.1 Chart and Vessel Display

3.1.1 Chart
The baseline display of the MNS shall be the representation of the electronic charts of the relevant waterways. The MNS shall be capable of displaying navigational charts in either DX90, or Admiralty Raster Chart Service format. Displayed chart shall form a perceived continuous image with full scroll, zoom, pan, clutter/declutter functions and colors conforming to IHO standard SP-52 requirements.

Safe and unsafe water depths shall be represented by different colors.

Displayed chart issue date shall be indicated on the screen.

It shall be possible to updates charts via floppy disk or CD-ROM.

It shall be possible to display charts in the following orientations:
    a. north-up
    b. vessel course-up
    c. vessel head-up (Ship-based MNS only)

Chart, vessel, and other navigational information shall be displayed in accordance with the following user selected units of measures:

    a. latitude/longitude: 1. degrees/minutes/decimal minutes
                                           2. degrees/minutes/seconds/decimal seconds

    b. depth: 1. meters/decimeters
               2. fathoms
               3. feet

    c. height: 1. meters
               2. feet

    d. distance: 1. nautical miles/decimal miles
               2. meters
               3. kilometers

    e. speed: 1. knots/decimal knots
               2. kilometers per hour

3.1.2 Vessel

The vessel shall be displayed as a scaled silhouette or an icon. The silhouette shall be scaled to the chart or the chart zoom level. When the vessel cannot be scaled accurately, it shall be displayed as an icon.

If a vessel enters a section of a raster chart for which a larger scale view is available, the MNS shall automatically display the larger scale chart.

The user shall have the option of positioning the vessel anywhere on the screen. The chart shall automatically redraw to maintain correct geographical representation.

A single action button shall be provided to allow the user to automatically locate the vessel at selected screen location. The chart shall automatically redraw to maintain correct geographical representation.

Two modes shall be available for vessel movement representation:
    a. relative: stationary vessel with chart scrolling
    b. true: moving vessel on stationary chart

It shall be possible to add two types of corrections to the positioning system data for precise vessel positioning:

a. offset: compensation for actual GPS receiver location relative to vessel longitudinal center (conning position)

b. user corrections: temporary compensation set by user

3.2 Navigation Overlays

The following navigation overlays shall be added to the chart display when requested by the user. Refer to table 5 to determine the overlays that shall be available for each system configuration.

3.2.1 Compass rose
It shall be possible to overlay on the chart a compass rose with true north and magnetic north reference. Corrections for magnetic deviation and variation shall be automatically updated based upon position and date.

3.2.2 Range rings
It shall be possible to select and center range rings on the vessel's position. Range rings shall be accurately scaled to the chart.

3.2.3 Latitude - longitude grid
It shall be possible to accurately display Latitude-Longitude lines to the scale of the chart. At normal viewing scale, the Latitude-Longitude lines shall be marked in 1/10 nmi increments

3.2.4 SAR/Plotting grid
It shall be possible to overlay user defined grid to the displayed on the chart. This grid shall be adequate for Search and Rescue and plotting operations.

3.2.5 Heading or COG line
It shall be possible to display a heading line indicating the direction of vessel's current heading as obtained from the gyro compass.

On systems where gyro input is not available, a COG line shall be displayed from data received from the positioning system.

The heading or COG line shall be a dashed line of 6 segments each corresponding to 1 minute of voyage.

3.2.6 Radar
When interface to radar is available, and radar display is selected, the MNS shall overlay the radar image to the chart. Chart scale and orientation shall be considered for radar image processing and matching of chart contours.

The radar gain and threshold shall be adjustable. Vessel positions shown on radar images shall be tagged, indicating stationary and moving vessels.

Radar target and ARPA-like information shall be displayed when available.

3.2.7 Event mark
An Event Mark button shall be available for indication of special condition occurrence.

If the event corresponds to a Man Overboard Button (MOB) condition, the MNS shall compute the man overboard location at the time of the alarm, and maintain directional information about how the vessel should proceed to intercept the man over board's present position.

Values to be calculated and maintained for the man overboard location, allowing for set and drift, and the vessel's position, shall include:

  a. range
  b. bearing
  c. elapsed time
  d. latitude-longitude
  e. set
  f. drift

Set and Drift shall be derived from the vessel in the vicinity of the MOB, using standard algorithms (the difference between speed through the water & heading, and COG & SOG). The Set and Drift obtained shall then be used to calculate the change of position of the MOB (environmental influences shall not be considered).

The SAR grid shall automatically be overlaid on the chart display upon activation of the Event Mark button.

3.2.8 Status Panel
The following information shall be displayed on a status panel:

  a. date (local/UTC)
  b. time (local/UTC)
  c. chart number
  d. cursor position (lat/long)
  e. cursor bearing and range relative to own ship
  f. own ship position, COG, SOG, X-track error
  g. waypoint position, course to steer, distance, ETA, TTG
  h. next waypoint position, course to steer, distance, ETA, TTG

The status panel shall be permanently displayed in the right hand section of the screen and shall not conceal chart displayed.

3.2.9 Positioning status
The following information shall be extracted from the positioning system and displayed upon user request:

  a. number of satellites being tracked

b. GPS operating mode

c. HDOP

d. SNR of satellites signals

e. DGPS signal strength

f. DGPS beacon station identification

3.2.10 Depth
Three types of depths shall be available for display:

a. chart depth

b. absolute depth

c. dynamic depth

By default, chart depth shall be displayed.

Absolute depth shall be calculated from chart sounder data and from user entered water level above datum, or COWLIS data. Absolute depth shall be displayed in a window.

The MNS shall calculate dynamic depth by integrating chart depth, COWLIS data (or depth sounder data and vessel draught), to tide information and ship speed. Chart depth contours and associated colors shall be redrawn to reflect predicted water depth along planned vessel route at time of passage. Up to 6 hours of predictions shall be provided.

3.3 Route Planning

Two modes of route planning shall be available:

a. manual

b. semi-automatic

After a route is planned, it shall be store in a route database. The number of route that can be stored in the route database shall be limited by available system memory only.

It shall be possible to modify the planned route, including the reversal of the route, either before or after it is stored in the database.

In both modes of route planning, the MNS shall be able to predict go/no-go situations along the vessel's planned route based on chart depth, and tide tables information. If a no-go situation is encountered along the vessel's planned route, an alarm shall sound and the user shall have the possibility of specifying an alternate route or an adjustment of the vessel speed. The system shall then check the alternate route for sufficient water depth to proceed.   If the primary and alternate routes are impassable because of water depth and tide, the MNS shall predict a speed that will make the vessel arrive at the obstacle when the tide has produced sufficient water depth to proceed.

3.3.1 Manual route planning
Manual route planning shall permit the navigator to plot the route on displayed chart by selecting waypoints.

The MNS shall provide the capability to check a manually entered route for sailing and sufficient depth under keel once a departure time is given.

3.3.2 Semi-automatic route planning
In the semi-automatic route planning mode, the MNS shall suggest the best route between navigator entered way points based on dynamic depth algorithms, time constraints and tidal conditions considerations. Recommended route shall be subject to navigator's acceptance or modification.

3.3.3 Range and bearing lines
It shall be possible to set Range and Bearing Lines (RBL) from the vessel to any point, or between any two points on the chart. The range and bearing to the point, or between the points, shall be displayed in the status window. Changes in vessel's position shall result in the update of the range and bearing information.

3.3.4 Parallel indexing
It shall be possible, in relative mode, to drop segments corresponding to planned land marks movement relative to the vessel.

3.3.5 Trial maneuvering
The MNS shall offer the capability to simulate, on the displayed chart, vessel movement based on user entered position, course and speed data.

3.4 Route Monitoring

3.4.1 Time to go
When sailing a planned route, the MNS shall calculate and display time to go to next waypoint.

3.4.2 Course to steer
The MNS shall display the course to be taken when passing a waypoint by indicating course to steer with an arrow head. A turning range circle centered on the waypoint shall indicate the range at which the turning maneuver must be initiated to leave the waypoint on the correct heading. The radius of the circle shall be selectable from a menu-assisted procedure to correspond to the class of the ship on which the MNS is mounted.

3.4.3 Dead Reckoning
Under positioning system input loss conditions, the dead reckoning (DR) navigation mode shall engage. In this mode, the last known vessel position shall be integrated to vessel course and speed sensor, or user entered data for a DR line calculation and display.

3.4.4 Collision avoidance

A handshaking protocol based on a trunking network architecture shall allow multiple ships to be networked on the same frequency. An RF data modem link shall automatically be established when two vessels are approaching each other. Vessel's position, identification and course information shall be communicated to the other vessels on the same radio frequency. Information received from other vessels shall be displayed on the chart (scale permitting) along with course and speed data.

3.4.5 Closest Point of Approach

The MNS shall calculate the closest point of approach (CPA) of waypoints, obstacles and approaching vessels. This CPA information shall be displayed in the status panel. The following CPA information shall be calculated and displayed:

        a. heading

        b. range

        c. bearing

        d. Time To Go (TTG)

        e. Estimated Time of Arrival (ETA)

3.4.6 Track record

The MNS shall automatically log and display a precise track of the vessel's voyage. Data recording intervals shall conform to ECDIS and shall guarantee at least 12 hours of track history (based on the fastest sampling rate of one sample per second). Sampling rate shall be modifiable by the mariner. The maximum recording duration shall be limited only by the physical disk capacity. Data compression techniques shall be used to ensure an efficient use of mass storage.

Playback of the track history log shall be activated through a simple pop-up menu. A backup procedure shall also be part of the MNS utilities.

3.5 Alarms & Alerts

Alarms and alerts (the two terms are used interchangeably in this section) shall take the form of a graphically distinguishable icon or symbol (flashing), audio, or an unusual event such as a printer starting up. They shall draw attention to an unusual condition, either present or future.

The possibility to connect system alarms to the vessel's emergency audio alarm system shall be provided.

The following alarms and alerts shall be provided by the MNS:

3.5.1 Anti-grounding alarm

The MNS shall determine a "depth watch" sector in front of vessel based on vessel's SOG, heading, and draught. Crossing of unsafe soundings by this sector shall trigger an audible and visual alarm.

3.5.2 Collision alarm
This alarm shall graphically and audibly notify the vessel's navigator of a potential collision with a fixed object or another vessel. This alarm shall be calculated by MNS in time for evasive action, based on the vessel's characteristics. Inputs shall be the electronic charts, RF modem data communications (if implemented in a two-way mode), and radar tracks of other moving vessels.

3.5.3 Depth alarm
This alarm shall be generated by the system if the vessel's current track will bring it into a grounding situation. The alarm shall be sounded in time for the vessel to avoid the situation.

3.5.4 Anchor alarm
This alarm shall indicate a dragging anchor or other vessel change from a desired static position.

3.5.5 Waypoint alert
This alert shall indicate the approach of a predetermined waypoint. The threshold in distance or time for this alert shall be navigator selectable.

3.5.6 Positioning system alarm
The following conditions shall be reported by the MNS:

   a. HDOP>set threshold

   b. tracked satellites<4

   c. loss of DGPS beacon signal

   d. time elapsed since last update exceeds set threshold

3.5.7 Cross-track error alarm
This alarm shall indicate that vessel's deviation from the planned route has reached the user defined threshold. The deviation shall be calculated perpendicular to the route.

3.5.8 Instrument failure alert
This alert shall indicate that one or more sensor inputs have been lost.

3.5.9 Gyro update alert
This alert shall indicate that the time elapsed since the last gyro update (heading) has exceeded the user defined threshold.

3.5.10 Self test alarm
The self test alarm shall indicate that the MNS has failed the self test.

3.5.11 Watch Alert
This alert shall sound when the system's keyboard or pointing device has not been used. Time threshold for this alert shall be selectable.

3.6 Electronic Books

The MNS shall provide an access method to electronic books to be used by the system. Information in these reference books shall be accessed using a full text search and retrieval system. Except for on-line help, the content of all other books is not covered by this specification.

Access to the following books shall be available:

a. On-Line Help: the MNS shall have a complete on-line help system

b. Sailing Directions: containing references to navigation aids, recommended routing, expected depths, and other pertinent information

c. Tide Tables: containing tide data of sailed area

d. List of Lights: containing a list of all the navigational aids on a waterway, including range lights, buoys, lighthouses, and other aids to navigation. The database shall be editable

e. Notes and Tags: containing user-entered notes and tags, reflecting unusual conditions or other pertinent information

f. Notices to Mariners: to maintain the timeliness of the various electronic books and charts

3.7 Complementary Requirements

3.7.1 Local area networking
The subsystems of the Ship-based MNS shall be capable of exchanging information through an Ethernet-type local area network.

3.7.2 Antenna group
The antenna group shall consist of the GPS receiver and antenna, the DGPS beacon receiver and antenna, the RF modem transceiver and antenna, an Ethernet interface, and a central processing unit.

GPS and DGPS signals shall be processed by the CPU for vessel position determination. The Ethernet interface shall handle all communications between the antenna group and the computer/display subsystem through an RF link for the Pilot system, and a hard wired connection for the Ship-based system.

3.7.3 Self test
The MNS shall integrate a self test routine which shall verify the major functions of the system. The MNS shall not need any peripherals or user inputs (other than self test button activation) to perform the self test.

3.7.4 Size & weight
The Pilot system configuration of the MNS shall be of size and weight to permit hand- carry on-board the vessel.

The Ship-based configuration shall be composed of one bridge and one chart room workstation. Each workstation's processing unit shall standard 19" rack mountable.

3.7.5 Configurations
The MNS prototype, Pilot, and Ship-based system configurations shall be per the following table.

Table 1 - MNS System Configurations

Section	Requirement	Prototype System	Pilot System	Ship-based System
2	**System Inputs**			
2.1	**Chart**			
2.1.1	Vector	✓	✓	✓
2.1.2	Raster		✓	✓
2.2	Positioning System	✓	✓	✓
2.3	Radar			✓
2.4	COWLIS		✓	✓
2.5	Serial Interfaces			✓
2.6	User	✓	✓	✓
2.7	RF Communications		✓	✓
2.8	Other Inputs		✓	✓
3	**Outputs & Displays**			
3.1	**Chart and Vessel Display**			
3.1.1	Chart	✓	✓	✓
3.1.2	Vessel	✓	✓	✓
3.2	**Navigation Overlays**			
3.2.1	Compass rose		✓	✓
3.2.2	Range rings		✓	✓
3.2.3	Latitude - longitude grid		✓	✓
3.2.4	SAR/Plotting grid		✓	✓
3.2.5	Heading or COG line	✓	✓	✓
3.2.6	Radar			✓
3.2.7	Event mark		✓	✓
3.2.8	Status panel	✓	✓	✓
3.2.9	Positioning status		✓	✓
3.2.10	Depth	✓	✓	✓
3.3	**Route Planning**			
3.3.1	Manual route planning	✓	✓	✓
3.3.2	Semi-automatic route planning		✓	✓
3.3.3	Range and bearing lines	✓	✓	✓
3.3.4	Parallel indexing		✓	✓
3.3.5	Trial maneuvering		✓	✓
3.4	**Route Monitoring**			
3.4.1	Time to go	✓	✓	✓
3.4.2	Course to steer	✓	✓	✓

Table 1 - MNS System Configurations

Section	Requirement	Prototype System	Pilot System	Ship-based System
3.4.3	Dead reckoning	✓	✓	✓
3.4.4	Collision avoidance		✓	✓
3.4.5	Closest Point of Approach			✓
3.4.6	Track record	✓	✓	✓
3.5	**Alarms & Alerts**			
3.5.1	Anti-grounding alarm	✓	✓	✓
3.5.2	Collision alarm			✓
3.5.3	Depth alarm	✓	✓	✓
3.5.4	Anchor alarm		✓	✓
3.5.5	Waypoint alert	✓	✓	✓
3.5.6	Positioning system alarm		✓	✓
3.5.7	Cross-track error alarm	✓	✓	✓
3.5.8	Instrument failure alert			✓
3.5.9	Gyro update alert			✓
3.5.10	Self test alarm		✓	✓
3.5.11	Watch alert		✓	✓
3.6	**Electronic Books**		✓	✓
3.7	**Complementary Requirements**			
3.7.1	Local area networking			✓
3.7.2	Antenna group	✓	✓	✓
3.7.3	Self test		✓	✓
3.7.4	Size & weight		✓	

4. Hardware Description

The proposed hardware platform for the Pilot and Ship-based MNS, and the antenna group are detailed below. This shall represent minimum hardware performance requirements.

4.1 Prototype system
   a. Intel i486 or higher μprocessor
   b. 32 MB of RAM
   c. 240 MB hard disk drive
   d. keyboard/pointing device
   e. 256 colors monitor

4.2 Pilot system
   a. Intel i486 or higher processor based portable computer
   b. 32 MB of RAM
   c. 240 MB hard disk drive
   d. High-resolution display
   e. Cordless Ethernet connection
   f. Auto switching 110/240 VAC power supply

4.3 Ship-based system
   a. Intel i486 DX2-66 or higher processor based computer
   b. 32 MB of RAM
   c. 1 GB hard disk drive
   d. 2 high-resolution screens (1280 x 1024)
   e. Pointer device (mouse, pen, touch-screen, trackball)
   f. Multi-port serial interface
   g. 1 parallel port
   h. PCMCIA interface
   i. Ethernet interface
   j. Uninterruptible power supply

4.4 Antenna group
   a. Intel i386SL 20 processor
   b. GPS receiver and antenna
   c. DGPS beacon receiver and antenna
   d. RF transceiver and antenna
   e. Cordless Ethernet connection
   f. Auto switching 110/240 VAC power supply

Appendix B

Radar Interface System Specifications

Appendix B

Radar Interface System Specifications

This system specification identifies the functional requirements to be met by the design of the Maritime Navigation System radar interface.

1. Applicable documents

The following documents are deemed to form an integral part of this specification. In case of conflict between this specification and any reference document, this specification shall take precedence.

Maritime Safety Committee MSC/Circ. 637 27 May 1994	Performance standard for Electronic Chart Display and Information System (ECDIS)
International Hydrographic Organization Special Publication No. 52	Provisional Specification for Chart Content and Display of ECDIS

2. Radar interface

2.1 Radar image

The MNS shall be capable of receiving and processing for display radar sweep images from digital and analog radars.

2.2 ARPA data

The MNS shall acquire and process for display ARPA data available from radar ARPA modules in standard NMEA 0183 sentences. NMEA 0183 sentence TTM shall be decoded.

The decoding of proprietary NMEA 0183 sentences shall be kept to a minimum to maintain interfacing flexibility.

3. Display of radar image and ARPA data

3.1 Overlay

It shall be possible to overlay ARPA designated targets and/or the radar image to the electronic chart containing the radar sweep area.

The radar image shall automatically be oriented and scaled to the electronic chart to which the image is overlaid.

The radar image display processing method shall not reduce system response time in an unsafe manner.

3.2 Separate window

It shall be possible to display ARPA designated targets and /or the radar image into a separate window without any electronic chart.

A window containing radar data exclusively shall have a black background.

Vessel position shall be displayed using applicable symbology.

3.3 Symbols and colors
ARPA targets shall be displayed using the VESSEL00 symbol as defined by the applicable ECDIS presentation library. This symbol includes a solid target course line of six (6) minutes of navigation in length.

Both ARPA targets and radar images shall be displayed using the ARPAT (or RADHI) color token.

4. Buttons and Controls

4.1 Single action button

A single action button shall be provided to turn off the overlay of any radar supplied data (ARPA and/or radar image).

Adding ARPA targets and/or radar image to a chart or separate window can be done through multiple operator actions.

4.2 Radar antenna offset

The MNS shall provide the operator with the capability to enter an offset for the radar antenna relative to the ship's conning position.

This offset shall be used to automatically match the radar image reference with the Global Positioning System reference and the ship's symbol.

4.3 Ship's position offset

It shall be possible for the operator to manually offset the ship's position on the electronic chart to match the electronic chart with radar detected land contours or ARPA reference targets.

An indication of entered manual offset shall be given while it is active.

4.4 Tools

The following MNS tools shall be active simultaneously in chart and radar windows sharing common coverage:

- Beam Bearing
- Electronic Bearing Line (EBL)
- Variable Range Marker (VRM)
- Cursor VRM
- Range Ring

It shall be possible to control these tools from either the chart or radar window.

Appendix C

User Trials Comment and Intervention Logs

Appendix C

User Trials Comment and Intervention Logs

Intervention Log

No.	Date	Syst.	Problem	Actions taken
1	20 Dec 94	1	General Protection Failure of application - Reason unknown - World map wouldn't open from toolbar button	Application closed and re-started. Log of event to be analyzed for clues.
2	20 Dec 94	1	General Protection Failure of GPS server after start-up of application following a GPF	Server closed and re-started prior to re-starting the application after a GPF.
3	20 Dec 94	1	Application froze twice - Reason unknown	Application closed and re-started. Log of event to be analyzed for clues.
4	23 Dec 94	1	Application froze several times	Resetted computer and restarted the application.
5	27 Dec 94	1	Nil	Installed: Application version 1.1 built 11 Server version 1.1.
6	27 Dec 94	1	Dynamic segment sometimes disappears when route planning while sailing	Terminated route planning action.
7	29 Dec 94	1	Current waypoint was lost	Reset the current waypoint. Investigate potential source of problem.
8	29 Dec 94	1	In one instance, the dynamic part of the past track was in error when new chart loaded	None

No.	Date	Syst.	Problem	Actions taken
9	29 Dec 94	1	Planned route not displayed in certain windows	None
10	29 Dec 94	1	The world map window would not open upon clicking the toolbar button	Opened chart through pull-down menu.
11	29 Dec 94	1	The displayed ENC layer locks in "Other information".	Re-loaded chart.
12	29 Dec 94	1	The range line point of origin does not remain on the vessel when cursor is moved out of the chart window.	None
13	12 Jan 95	1	Nil	Installed: Application version 1.1 built 18.
14	13 Jan 95	1	The VRM looses it's attachment to the ship after an automatic recentering.	Moved cursor. The VRM re-attached to the ship automatically.
15	13 Jan 95	1	Automatic recentering did not occur while other chart manipulations were performed.	Forced a recentering using the "home ship" toolbar button.
16	13 Jan 95	1	Vessel symbol still appeared on a chart that was no longer sailed.	None
17	28 Jan 95	1	Nil	Installed: Application version 1.1 built 20.
18	7 Feb 95	1	Loss of differential corrections to GPS.	Replaced the MX 4200D GPS receiver. Also replaced the 12VDC power supply and the cabling for a more compact installation.

No.	Date	Syst.	Problem	Actions taken
19	24 Mar 95	1	Nil	Installed:
20	24 Mar 95	1	Set recenter region and homing position are altered by chart changes.	Resetted the recenter region and homing position.
21	24 Mar 95	1	Charts are re-tiled when a different status panel size is selected from the menu.	Maximized the current chart window.
22	11 Apr 95	2	Nil	Installed: Application version 1.2 built 8 DX90 Viewer version 1.2 built 8
23	11 Apr 95	2	The system responded very slowly when the zoom level exceeds 200X.	Returned the zoom level to within 30X. System operation was back to normal.
24	11 Apr 95	2	Tools could not be activated from the numerical keypad.	Activated one tool from the pull-down menu. Activation of all tools from the numerical keypad was then possible.
25	11 Apr 95	2	The GPS server still indicated 3D navigation after going to the Dead Reckoning mode.	None.
26	11 Apr 95	2	Several scale bars and north indicators appeared on the chart when simultaneously sailing and planning a route (occurs when panning through the chart).	None. Route planning operation not affected.

No.	Date	Syst.	Problem	Actions taken
27	11 Apr 95	2	GPS server still indicated a HDOP of 1.3 when other shipboard GPS reported 3.5 (same 3.5 HDOP value was reported by another ship within the same vicinity).	None.
28	11 Apr 95	2	The past track sometimes leaves garbage (small black bars) on the chart until it is redrawn.	Forced a redraw of the chart.

Comment Log

No.	Date	By	Comment
1	20 Dec 94	Pilot	The MNS should create a route at a specified port or starboard distance from the chart navigation lines.
2	20 Dec 94	Pilot	Access to alarms volume should be provided.
3	20 Dec 94	Q-MAR	The COG line can be misleading during docking maneuvers. Important to add heading information.
4	20 Dec 94	Q-MAR	There is a preference for automatic features over manual features.
5	20 Dec 94	Pilot	Should be able to select a desired contour line.
6	20 Dec 94	Q-MAR	User defined window configurations should be available.
7	20 Dec 94	Captain	Are charts automatically loaded or maximized when sailed by vessel?
8	20 Dec 94	Pilot	The last zoom action should be "undoable".
9	20 Dec 94	Captain	It should be possible to plan a route on a blank charts for areas where electronic charts are not available
10	20 Dec 94	Captain	A line should be added after each verbose pick (chart interrogation) in the chart information window.
11	20 Dec 94	Captain	Radar terminology should be used. For example, "panning" should be "shift".
12	20 Dec 94	Captain	Certain global system information should always be displayed, and closed by single operation.
13	20 Dec 94	Pilot	Buoy are too large on the chart.
14	20 Dec 94	Pilot	The different chart scales should be available from keyboard shortcuts.
15	20 Dec 94	Q-MAR	Function keys should be used to provide programmable setups.
16	20 Dec 94	Q-MAR	In the cross-track error of the status panel, "starboard" should read "SB" and "port" should read "Port" or "P".

No.	Date	By	Comment
17	20 Dec 94	Q-MAR	A third decimal should be added to the nautical miles range data of the status panel.
18	20 Dec 94	Q-MAR	Pointing device speed should be reduced.
19	20 Dec 94	Pilot	It should be possible to obtain the ETA of any waypoint.
20	20 Dec 94	Pilot	We foresee a maximum of three scales being used.
21	20 Dec 94	Captain	The World, Approach, and Harbor scales offered by the Robbertson are well liked.
22	20 Dec 94	Pilot	It should be possible to display a range ring of variable size centered on the vessel.
23	20 Dec 94	Captain	The world map should clearly indicate which charts are open, and prevent re-opening of those charts, and display the vessel.
24	20 Dec 94	Pilot	Waypoint constants shall be modifiable within the application (as opposed to the MNS.INI file)
25	20 Dec 94	Pilot	The vessel's pivoting point could be calculated from the screw speed, speed through the water, and other factors, or could also be manually selected.
26	27 Dec 94	Captain	Night color palettes are too dark.
27	27 Dec 94	Captain	The cursor should have its own variable (3 levels) brightness control.
28	27 Dec 94	Captain	Ship's double concentric circles symbol does not provide a realistic representation of ship's position. At large scale, ship silhouette with cross at conning position would be more representative.
29	27 Dec 94	Captain	A "restricted waters" option should be available to deactivate ship's safety area and avoid the triggering of alarms.
30	27 Dec 94	Captain	When a chart is loaded, it should be displayed at its compilation scale.

Comment Log

No.	Date	By	Comment
31	27 Dec 94	Captain	The alarm window should be moved from its present prime screen area. It's not being monitored anyway. It would be preferable to indicate current working status such as: number of next chart, selected sounding option, alarms activated or not, tide and current.
32	27 Dec 94	Captain	Chart number of iconized chart is too small.
33	27 Dec 94	Captain	Add keyboard shortcuts (e.g. alt S = sounding, alt C = contour ...).
34	27 Dec 94	Captain	System is slow. There is sometimes a delay of a couple of seconds after the selection of an option.
35	27 Dec 94	Captain	An indication should pop-up when the system freezes.
36	29 Dec 94	Q-MAR	The system should indicate when GPS signals are restored after failure.
37	29 Dec 94	Pilot	A list of waypoints should be available to easily determine the Time To Go to a specific waypoint.
38	29 Dec 94	Q-MAR	The toolbar button label may appear underneath the cursor thus sometimes preventing clicking of button.
39	29 Dec 94	Captain	The Chart Info window obstruct the display when minimized.
40	29 Dec 94	Captain	The alarms and look ahead safety region are not utilized by the mariners (they suggest the possibility to turning them off).
41	29 Dec 94	Q-MAR	An indication of which chart the vessel is on could be added.
42	29 Dec 94	Q-MAR	The vessel's position log with the alarms should use the same format as the lat/long in the status window.
43	29 Dec 94	Q-MAR	Redraws caused by menus slow down the system.
44	29 Dec 94	Q-MAR	An indication of the current rate of turn could be added.
45	29 Dec 94	Pilot	It should be possible to fix the range line at 90º of vessel heading.
46	29 Dec 94	Pilot	There should be a 3/4 nmi fix range selection available.

Comment Log

No.	Date	By	Comment
47	29 Dec 94	Pilot	Cursor bearing and range are important information that should be clearly distinguishable from other information in the status window.
48	29 Dec 94	Q-MAR	There should an automatic ship homing after restoring a chart window which has been manipulated.
49	29 Dec 94	Q-MAR	In route planning mode, the cursor range and bearing should be relative to the last entered waypoint.
50	13 Jan 95	Pilot	There should be an indication of the current range of the chart window.
51	13 Jan 95	Pilot	It should be possible to have range rings centered on the ship.
52	13 Jan 95	Captain	It should be possible to add comments to the chart, and change object attributes (e.g. modify a summer buoy to a winter buoy)
53	13 Jan 95	Pilot	A relative motion mode should be available.
54	13 Jan 95	Pilot	Buoys should be appropriately colored.
55	13 Jan 95	Pilot	Color should be used to highlight the SOG and COG information in the status window.
56	13 Jan 95	Pilot	Light symbol orientation is incorrect. Think it should be 0º.
57	13 Jan 95	Captain	Waypoint information is not very useful as presented. It would be preferable to provide the capability to select any waypoint and determine ETA based on current speed, or determine the required speed for a given ETA.
58	13 Jan 95	Q-MAR	Identification of loaded route should be given.
59	13 Jan 95	Q-MAR	It should be possible to modify a saved route (re-locate waypoints).
60	13 Jan 95	Pilot Captain	A method of escaping the Night Unfiltered color palette should be given when selected in daytime.
61	13 Jan 95	Captain	The various methods of zooming are confusing. These should be consolidated into one or two options.

Comment Log

No.	Date	By	Comment
62	13 Jan 95	Captain	The scale and range boxes should indicate the last selection.
63	13 Jan 95	Pilot	An indication of the accuracy level of the GPS positioning should be given.
64	13 Jan 95	Captain	In Dusk Black Back mode, most OK and CANCEL buttons in dialog boxes are not visible.
65	24 Mar 95	Pilot	The gap between the COG lines is confusing. The COG line should be a solid graduated line.
66	24 Mar 95	Captain	Scale selection should be simplified by using keyboard keys to increase and decrease the scale by fix values.
67	24 Mar 95	Pilot	North orientation should be indicated.
68	24 Mar 95	Pilot	GPS/DGPS data (number of tracked satellites, navigation mode) should be indicated.
69	24 Mar 95	Pilot Captain	Chart objects should not be duplicated on the chart (like it is the case on several of them).
70	24 Mar 95	Pilot	It should be possible to run a replay of a voyage from the log.
71	11 Apr 95	Captain	Next Waypoint information should be replaced by bearing and distance to next buoy in the status window.
72	11 Apr 95	Captain	The distance between the vessel and theoretical buoy position should be indicated.
73	11 Apr 95	Captain	The past-track is useful but should be smaller (narrower) so that the display will not be cluttered when the vessel is almost stationary.
74	11 Apr 95	Captain	It should be possible to display a circle of a given radius centered on the vessel or any given point.
75	11 Apr 95	Captain	The zoom in/out functions should be accessible while adding waypoints in the route planning mode.

No.	Date	By	Comment
76	11 Apr 95	Captain	It should be possible to modify the type and attributes of buoys on the chart.
77	11 Apr 95	Captain	The zoom functions should be accessible from the keyboard. It is suggested that a standard zoom in/out of 2X be utilized, with another key for smaller increments.
78	11 Apr 95	Captain	"Head-up" display, or at least "choice-up" (manually entered) should be available.

Appendix D

Ship-based Configuration Test Results

(*Not available in electronic format*
Non disponible en format électronique)

Appendix E

Pilot Configuration Test Results

(*Not available in electronic format
Non disponible en format électronique*)