PROCEDURES MANUAL FOR DESIGN AND REVIEW OF MARINE SHORT-RANGE AIDS TO NAVIGATION SYSTEMS

Canadian Coast Guard
Transport Canada

March, 1989

TP9677E

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1. INTRODUCTION

1.1 Purpose

This manual has been designed to provide operational and technical procedures to give effect to two directives: Directive 2-2200, "Design of Short-Range Marine Aids Systems" and Directive 2-2600, "Review of Short-Range Marine Aids Services."

Traditionally most aids to navigation have been provided on a "user-demand" basis. The response to such user requests or demands have been at the local or district levels by district staff having many years of experience and the resulting knowledge of Canadian aids to navigation practices. They have evaluated the needs and recommended the aid or aids to navigation that best suited the location and the user, taking into consideration, to the extent possible, the costs and benefits of providing and maintaining these aids.

Although, for some time, there have been national policies and guidelines to assist in selection of the appropriate aids what has been lacking is a set of standard procedures to ensure the consistent and equitable application of these policies and guidelines. This manual has been designed to meet this requirement and to enable documentation of the step-by-step procedures in a logical sequence in order to justify the conclusions and recommendations of the design or investigating office.

These procedures will allow Coast Guard to:

- simplify cyclical and other reviews of established aids to navigation through documented analysis;
- move toward a safe and equitable level of service across the country;
- identify future resource requirements.

1.2 Scope

This manual incorporates operating and technical procedures for designing new/optimal short-range marine aids systems and for reviewing existing systems. The policies guiding design and review are set out in Directive 2-2200, "Design of Short-Range Marine Aids Systems" and Directive 2-2600, "Review of Short-Range Marine Aids Services". Instructions for the organization of reviews are given in the latter directive.

This manual deals only with short-range marine aids. It does not deal with situations where such aids are insufficient and, therefore, alternatives (e.g., pilots, tugs, VTS) may be required. Nor does it deal with design features or redundancies that are needed primarily to facilitate adherence to policies for on-site checking or responses to discrepancies.

1.3 Overview of Procedures

The procedures for determining the requirements for short-range marine aids at any site are based upon four types of analysis:

(a) An analysis of users, traffic patterns, weather and possible navigational threats at the site (site analysis).

(b) An analysis of user needs for navigational markers and signals at the site (needs analysis) to help mariners cope with navigational threats.

(c) An analysis of outputs of various combinations of short-range aids that could be provided at the site (operational analysis) to identify feasible means of meeting user needs.

(d) A comparative analysis of cost of effective combinations of aids (cost-effectiveness analysis) to select between viable alternatives.

In brief, the steps to be followed in these procedures are:

(1) Specify the navigation site to be analyzed by identifying the user's traffic patterns and plotting the track or tracks on the chart. Gather all user and site information such as size, type and number of vessels, type, size, output and characteristics of all established aids to navigation, weather and sea conditions, previous reviews, marine incidents, requests, etc.

(2) Identify and classify the size and number of users according to the three basic categories.

(3) Rate the threats at each site for each type of user, using guidelines and professional judgement.

(4) Identify any local means, other than short-range aids to navigation, that may meet any of the needs identified.

(5) For each of the threats in the waterway, identify the related navigation needs and the aid or aids which address these needs.

(6) Identify any threats that are not adequately reduced and the recommended aids or other means that could meet the navigational need.

(7) Identify any aids to navigation that are provided where the threats are not significant or service is redundant and recommend action to reduce or discontinue aids.

(8) Calculate the coverage and hazard marking requirements at any open water landfall situation, for each user group.

(9) Calculate the equipment output required to achieve the required visual, aural and radar coverage at the specified level of availability. Identify where the requirements are not being met with established equipment and propose viable options.

(10) Calculate the size and output requirements for each aid to navigation established or proposed, in the confined section of the waterway, to meet the proposed availability for each user group. Identify where the proposed levels are not being met and propose viable options.

(11) Establish the comparative direct costs of each proposed alternative, to assist in determining the most cost-effective system of aids to navigation.

Policies, guidelines and operational standards are identified, wherever possible, to support the analysis. A number of forms and guidelines are available to allow complete documentation of the analysis. Although the manual contains guidelines to rate threats and select aids to navigation, a great deal of professional judgement and local knowledge must be used, particularly in the needs analysis.

The operational analysis is supported by a wide variety of standards. Whenever possible in the absence of standards, the manual provides guidelines. The achievement of appropriate results, however, depends on the good judgement of those using this manual and the site user consultations required to complement these procedures.

1.4 Overview of Manual

This manual is organized to reflect the four types of analysis previously outlined.

Chapter 2 provides the procedures and explains the forms to be used to collect and record the basic data about the site. This basic data is needed for the site analysis, needs analysis and operational analysis. An example is included to show completed forms.

Chapter 3 sets out the procedures and explains the forms used for the preliminary site analysis and rating of threats. An example is provided to show how the procedures and forms work.

Chapter 4 provides the procedures and forms required to conduct a needs analysis, together with an example. The navigation requirements vary between the basic types of locations or conditions. The first condition is an open water or dead-reckoning navigation situation, such as making first landfall or coasting from headland to headland (point-to-point navigation), where the navigational accuracy of the user is the main factor in determining what aids to navigation are required. The second condition is a confined water or piloting situation where dead-reckoning navigation may still be a factor, but where the main factor in determining what aids to navigation are required is the size and manoeuvrability of the vessel. While the general procedures for carrying out a needs analysis are the same for the two sets of conditions, the forms, incorporating the specific types of needs, are slightly different.

The two different types of conditions require different modes of operational analysis. Thus, while Chapter 5 sets out the procedures to be used for an operational analysis of open water/outer approaches, Chapter 6 provides these for confined water/inner approaches. Examples are being prepared and will be added to the Manual.

The procedures, forms and benchmarks for cost-effectiveness analysis are still under development. Therefore cost-efficient selection between viable options has, at this time, been left to judgement of the knowledgeable local managers and incorporated only as a final step in Chapters 5 and 6.

A list of supplementary references is given after Chapter 6, followed by the appendices which include a set of tables and figures providing relevant performance data on standard types of aids and components, a glossary of terms and technical instructions for landfall design.

2. BASIC SITE DATA REQUIREMENTS AND SOURCES

2.1 General Requirements

In accordance with Directive 2-2600, "Review of Short-Range Marine Aids Services" (item 3.3), all marine aids provided in each district must be separated into natural clusters or "systems" of aids that, together, serve the needs of mariners in an area or "site". These designated systems are the units for planning reviews (and inspections).

Specific data and materials must be compiled prior to undertaking the design, modification or review of a Short-Range Marine Aids system. The basic site data requirements are:

(a) The Canadian Hydrographic Services (CHS) Charts, Tide and Current Tables and Sailing Directions that cover the site.

(b) An inventory of all aids provided at the site by CCG.

(c) Information on the users of the site.

(d) Information on the weather and sea conditions at the site.

(e) Information on the physical geography of the site.

The site inventory is to be prepared on the forms provided, as discussed in Section 2.2 and the example given in Section 2-6. Historical information on weather and sea conditions is to be obtained from the Atmospheric Environment Services (AES), as set out in Section 2.3. Key elements of information on users, weather and sea conditions, and the physical geography of the site are to be abstracted from various sources and entered on the Site Data Sheet, as outlined in Sections 2.4 and 2.5.

2.2 Preparation of Site Inventory

When modification of a system is being contemplated, or a review planned, an inventory of all the aids provided by CCG at the site must first be prepared. This inventory is to be prepared on the Site Inventory Forms provided (see following pages).

The first step is to complete the "Marine Aids Site Inventory and Technical Data" form, listing all aids at the site with the following data:

(1) Aid Number: For buoys use the number from the Buoy Data Card. For fixed lights use the number from the List of Lights. For other aids use whatever local number identifies the aid.

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MARINE AIDS SITE INVENTORY SUMMARY

AIDES À LA NAVIGATION SOMMAIRE DE L'INVENTAIRE DE L'EMPLACEMENT

District	Charts / Cartes	Site / Emplacement	Date

Enter the total number at the site for each category — *Pour chaque catégorie, inscrire le nombre total à l'emplacement*

1. FIXED AIDS		**1. AIDES FIXES**
1.1 Major lights (≥ 10 n. miles nominal range)	☐	1.1 Feux primaires (≥ 10 m. marins portée nominale)
1.2 Minor lights (<10 n. miles nominal range)	☐	1.2 Feux secondaires (<10 m. marins portée nominale)
1.3 Ranges* : Lighted	☐	1.3 Alignements* : Lumineux
: Unlighted	☐	: Non lumineux
1.4 Day beacons	☐	1.4 Balises de jour
1.5 Radar reflector beacons	☐	1.5 Balises avec réflecteurs radar
1.6 Major fog signals (>1n.mile nom. range)	☐	1.6 Signaux de brume primaires (>1 m. marin portée nom.)
1.7 Minor fog signals (≤ 1n. miles nom. range)	☐	1.7 Signaux de brume secon. (≤1 m. marin portée nominale)
1.8 Racons on fixed structures	☐	1.8 Racons sur ouvrages fixes
1.9 Others:____________________	☐	1.9 Autres : ______________________
(specify)______________________	☐	(préciser) ______________________
Sub-Total	☐	**Total partiel**
2. FLOATING AIDS		**2. AIDES FLOTTANTES**
Lighted buoys:		Bouées lumineuses:
2.1 Large: Whistle (9'6" diam.; 6000kg)	☐	2.1 Grandes: sifflet (9'6" diam.; 6000kg.)
2.2 Large: Bell or fog signal (9'6" diam.; 4400kg)	☐	2.2 Grandes: cloche ou signal de brume (9'6" diam.; 4400kg.)
2.3 Medium (4' to 6' diam.; 1900-3000kg)	☐	2.3 Moyennes: (4' à 6' diam.; 1900-3000kg.)
2.4 Small (< 4' diam.; 1000kg)	☐	2.4 Petites: (< 4' diam.; 1000kg.)
Unlighted buoys:		Bouées non lumineuses:
2.5 Large (ice spars; > 600kg)	☐	2.5 Grandes (espars d'hiver; > 600kg.)
2.6 Medium (175 to 600kg)	☐	2.6 Moyennes (175 à 600kg.)
2.7 Small (< 175kg)	☐	2.7 Petites (< 175kg.)
2.8 Racons on buoys	☐	2.8 Racons sur bouées
2.9 Others: ____________________	☐	2.9 Autres:______________________
(specify) ______________________	☐	(préciser)______________________
Sub-Total	☐	**Total partiel**
TOTAL NUMBER OF AIDS AT SITE	☐	**NOMBRE TOTAL DES AIDES À L'EMPLACEMENT**

(* count ranges not structures or lights; pairs or single station count as one)

(* compter les alignements et non pas les ouvrages ou feux; une paire ou une station simple se compte comme un)

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MARINE AIDS SITE INVENTORY AND TECHNICAL DATA

District ____________ Site ____________ Charts ____________ Date ____________

DESCRIPTION			Daylight Visual Range	Radar Range	LIGHT SIGNAL								SOUND SIGNAL			GENERAL HISTORY	
Aid N°	General Category (see summary)	Particulars (name, type, size seasonality, etc.)	n. miles		Lantern Type and Size	Rotation/ Flash Duration	Lens Type and Colour	Bulb: Type	Bulb: Voltage	Bulb: Amps/ Watts	Bulb: Candelas	Nominal Range n. miles	Horn: db	Horn: Hz	Nominal Range n. miles	Year Established	Circumstances, etc.

(2) **General Category:** Use the categories set out on the form "Site Inventory Summary." Use the numbers and/or names.

(3) **Particulars**: Use this space to note details about the aid such as the common name (e.g., "Wreck Rocks Lighthouse"), type and size of structure, buoy or markings, the fact that it is replaced by a spar in winter, etc.

(4) **Daylight Visual Range:** Indicate here the normal maximum distance from which the aid can be seen under clear weather daylight conditions. Tables A.1 and A.2 in Appendix A may assist in determining this range.

(5) **Radar Range:** Specify here the normal maximum distance from which the aid itself is radar visible. If the aid itself is poor radar target, or is a poor target because of surrounding objects, simply note the problem in this column.

(6) **Light Signal:** Note here the characteristics and technical details about any light which is part of the aid. Tables A.3 and A.4, in Appendix A, may be used to derive the nominal range.

(7) **Sound Signal:** Note here the Db and Hz values of any fog signal. Table A.5, in Appendix A, may provide, or assist the determination of, the nominal range.

(8) **General History:** If known, specify the year in which the aid was first established and any special circumstances which lead to the provision of the aid (e.g., request from local fishermen, after an accident).

Once this detailed form has been completed, the aids can be counted by General Category and the counts entered on the "Site Inventory Summary." This latter form provides an overview of the system and allows quick comparisons for changes from one review to the next.

2.3 Obtaining AES Marine Climatological Data

AES maintains a databank of historical observations on weather and sea conditions. Selected outputs from this system are needed to assess potential threats to navigation and to assess operational performance of alternative system configurations. This data may be obtained through their regional offices or directly from:

Chief, Applications and Impact Division
Atmospheric Environment Services
Environment Canada
4905 Dufferin Street
Downsview, Ontario
M3H 5T4 (416) 667-4833

The following tables are required:

(a) Percentage Frequency Distribution of Precipitation, Potential Icing Rate due to Freezing Spray (monthly)

(b) Percentage Frequency of Visibility and Good Shipping Weather (monthly)

(c) Percentage Frequency of Wind Speed by Direction (annual Jan 1 to Dec 31, or, when applicable, for the restricted navigation season)

(d) Percentage Frequency of Combined Wave Height by Direction (annual, Jan 1 - Dec 31, or, when applicable, for the restricted navigation season)

(e) Percentage Frequency of Wind Speed by Direction (monthly - 12 tables)

These tables are normally available in data sets containing other similar tables. They may have to be carefully selected from the sets to ensure that correct data are used in the analysis.

In order to provide this information AES requires each site to be identified by name with the corresponding latitude and longitude points defining that area.

These coordinate points must be ordered in a clockwise rotation to the nearest tenth of a degree latitude and longitude.

Example:

Site	Pt. 1	Pt. 2	Pt. 3	Pt. 4
Ile d'Orleans to Pont Laporte	Lat(N)/Long(W) 46.9° 71.3°	Lat(N)/Long(W) 46.9° 71.1°	Lat(N)/Long(W) 46.7° 71.1°	Lat(N)/Long(W) 46.7° 71.3°

These parameters enable the AES program to collate all ships' observations within the specified area.

While, ideally, it would be appropriate to specify only the precise site, separating inner and outer approaches, the number of observations that AES has varies considerably from one area to another and there may not be sufficient data to draw conclusions from the precise area alone. Thus, to get usable data, it may also be necessary to specify larger areas (combining inner and outer approaches, going X miles further out) and/or to acquire data from adjoining areas that can be used to interpolate results for the site in question (see next section).

The costs for the data set you request will be invoiced to you by journal voucher from AES according to the responsibility cost code provided at the time you place your order.

2.4 Completion of Site Data Sheet

This form (see copy next page) is used to collate and summarize site data on traffic, weather and sea conditions and physiography used to assess threats to navigation, using various data sources as noted. The term "local knowledge" refers primarily to the knowledge of the locality held by CCG staff (fleet, Aids maintenance technicians and others who work at the site regularly), but may also require consultation with knowledgeable users of the aids system at the site. When using "local knowledge" for this exercise, always list the persons providing specific information, plus copies of any interview guides or questionnaires used to solicit the information, as documentation for the project.

First complete the heading to specify the site by noting the date, the CCG District, the relevant CHS chart(s), and the common name of the site. Then complete the data items from specified sources as follows:

(1) **Navigation Season:** From local knowledge, enter the navigation season for each applicable category of vessels as "all year" or as the normal opening and closing months for the season. For definitions of the vessel categories, see the Glossary of Terms (Appendix). In applying these definitions, note that all qualifications must be met, especially for Category I vessels. Merely carrying radar and/or other electronic equipment does not qualify a vessel as Category I. This equipment must be in accordance with all regulations (including inspection) and the operator must be trained, certified and able to use the equipment properly.

The information from this item is used to specify parameters for items (5) and (6) and to assess relevant threats.

(2) **Maximum Ship Size:** From available data sources or local knowledge enter the maximum size of vessel using the site for each applicable category. This data is used to identify hazards and to assess threats from restricted visibility, sea conditions and physical geography.

(3) **Volume of Traffic:** From local knowledge, user questionnaires, the databank collated for CCG's Base Capital Investment Plan and, where applicable, Vessel Traffic Services, Fisheries and Oceans data banks and staff, and provincial recreation and fisheries personnel, estimate the volume of traffic by type as number of users and number of transits. This data is used to assess safety problems arising out of traffic density.

(4) **Night-time Usage:** From local knowledge or user questionnaires, enter here the percent of users who operate at night for each applicable

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Date ....

MARINE AIDS / AIDES À LA NAVIGATION
SITE DATA SHEET / DONNÉES D'EMPLACEMENT

DISTRICT .... CHARTS / CARTES .... SITE / EMPLACEMENT ....

1 NAVIGATION SEASON	Long-Range Commercial	I		I	Commerciaux de longue portée — SAISON DE NAVIGATION 1
	Local Commercial	II		II	Commerciaux locaux
	Pleasure Craft	III		III	Bateaux de plaisance

2 MAXIMUM SHIP SIZE		Gross / Brut	Length / Longueur	Beam / Largeur	Draught / Tirant d'eau		GRANDEUR DE NAVIRE MAXIMUM 2
Long-Range Commercial	I					I	Commerciaux de longue portée
Local Commercial	II					II	Commerciaux locaux
Pleasure Craft	III					III	Bateaux de plaisance

3 VOLUME OF TRAFFIC		Number of users / Nombre de navires	Number of transits / Nombre de traversées		VOLUME DE TRAFIC 3
Long-Range Commercial	I			I	Commerciaux de longue portée
Local Commercial	II			II	Commerciaux locaux
Pleasure Craft	III			III	Bateaux de plaisance

4 NIGHT-TIME USAGE % USERS OPERATING IN DARKNESS					USAGE À LA NOIRCEUR % DE NAVIRES QUI CIRCULENT LA NUIT 4
Long-Range Commercial	I		I	Commerciaux de longue portée	
Local Commercial	II		II	Commerciaux locaux	
Pleasure Craft	III		III	Bateaux de plaisance	

		OUTER APPROACHES - APPROCHE EXTÉRIEURE / OPEN WATER - EAUX LIBRES	INNER APPROACH - APPROCHE INTÉRIEURE / CONFINED WATER - EAUX RESTEINTES		
5 VISIBILITY % TIME VISIBILITY EQUAL TO OR GREATER THAN (nautical miles) (worst month of navigational season)	.5			.5	VISIBILITÉ % DE TEMPS OÙ LA VISIBILITÉ EST ÉGALE OU SUPÉRIEURE À (milles marins) (mois le plus mauvais de la saison de navigation) 5
	1.1			1.1	
	2.2			2.2	
	5.4			5.4	
6 FREEZING SPRAY % OCCURRENCE (worst month of navigation season)	Moderate			Modérée	EMBRUNS VERGLAÇANTS % DE FRÉQUENCE (mois le plus mauvais de la saison de navigation) 6
	Heavy			Forte	
	Severe			Dangereuse	
7 WIND SPEED % TIME WIND EXCEEDS (Knots) (navigation season)	10			10	VITESSE DU VENT % DE TEMPS OÙ LE VENT DÉPASSE (noeuds) (saison de navigation) 7
	20			20	
	25			25	
	30			30	
	35			35	
	40			40	
8 WAVE HEIGHT % TIME WAVE HEIGHT EXCEEDS (Meters) (navigation season)	1			1	HAUTEUR DE VAGUE % DE TEMPS OÙ LA HAUTEUR DE VAGUE DÉPASSE (mètres) (saison de navigation) 8
	2			2	
	3			3	
	4			4	
	5			5	
	6			6	
9 TIDE RANGE/FLUCTUATING WATER DEPTH (Feet)					AMPLITUDE DE MARÉE/VARIATIONS DE LA PROFONDEUR D'EAU (pieds) 9
10 MAXIMUM CURRENT (Knots)	Along track			Dans le sens de la route	COURANT MAXIMUM (noeuds) 10
	Across track			En travers de la route	
11 CHANNEL SILTATION ? (Yes/No)					ENVASEMENT DU CHENAL ? (oui/non) 11
12 DISTINCTIVE SHORELINE FEATURES ? (Yes/No)	Visual			Visuelles	PARTICULARITÉS DISTINCTIVES DU RIVAGE (oui/non) 12
	Radar			Radar	

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category. This data is used to assess the need for lights and other means of navigating in darkness.

(5) **Visibility:** Where good AES data (i.e. from 200 or more readings) is available on the site, use AES data tables "Marine Climatological Studies: Percentage Frequency of Visibility and Good Shipping Weather" to complete this item. For the worst month during the full navigation season at the site invert the percentages and enter the percent of time that visibility is equal to or greater than .5, 1.1, 2.2 or 5.4 miles. (Note that the tables provide percentage frequency of visibility equal to or less than .5, 1.1, 2.2 and 5.4 miles). At sites where there is both an open water outer approach and a confined water inner approach, the data should be requested for each of these two sub-areas separately and jointly (in case there are insufficient reachings for one or both sub-areas). Where AES does not have good data on the specific site, it may be necessary to expand the coverage area somewhat in order to have sufficient readings. Where this does not suffice, review AES data to see if there are two nearby areas bracketing the specific site and for which AES does have sufficient readings. If so, interpolate and estimate visibility frequencies for the site. If this is not feasible, use local knowledge to make reasonable estimates. This data on visibility is used to assess threats from restricted visibility. It is also used in the operational analysis to assess the required spacing of aids (e.g., into a one mile visibility system) to meet the Design Availability standards of Level of Service and to assess the need for other measures when visibility requirements cannot be met by proximity of aids alone.

(6) **Freezing Spray:** In accordance with the procedures noted in (5), use the AES data table "Percent Frequency Distribution of Precipitation Potential Icing Rate due to Freezing Spray" or local knowledge to complete this section and enter the proportion of time during the worst month of the full navigation season (i.e. the longest navigation season for the three types of vessels) that freezing spray is moderate or worse, heavy or worse, or severe. This data, in conjunction with local knowledge of any problems with ice in the passageway during the navigation season, is used to assess the need for fixed offshore (eg., dolphins, piers) and onshore aids rather than, or as back-up to, floating aids.

(7) **Wind Speed:** In accordance with the procedures noted in (5) use the AES data table "Percentage Frequency of Wind Speed by Direction" or local knowledge to complete this section and enter the proportion of time during the full navigation season that the wind speed from all directions exceed 10, 20, 25, 30, 35, and 40 knots. Note that this data will have to be requested for the months that the site is in use by one or more of the three categories of vessels, as shown in item (1). Note also that while winds blowing across the normal track of movement are usually considered the most problematic, to allow for all vessel manoeuvring and potential problems, wind speeds have to be taken into account

regardless of the wind directions. This information is used to assess possible problems of "crabbing" and of maintaining safe distance from hazards and other vessels, and thus to establish the need for markers for lateral motion, hazards markers, boundary markers, etc.

(8) **Wave Height:** In accordance with the procedures noted in (5), use the AES data table "Percentage Frequency of Combined Wave Height by Direction" or local knowledge to complete this section and enter the proportion of time that the combined wave height exceeds 1, 2, 3, 4, 5, or 6 meters. Note that this data also has to be requested for the navigation season. This information is used both to assess threats from sea conditions and, in conjunction with charts, tide range and vessel draught, to identify submerged hazards (i.e. where the low water level, allowing for swell, does not provide sufficient under-keel clearance, according to the type and size of vessel).

(9) **Tide Range:** Use CHS Tide and Current Tables, CHS Sailing Directions, and, if necessary, local knowledge, to complete this item. It is used in conjunction with charts, wave height and vessel draught to identify submerged hazards and is also taken into account in assessing combined impacts of sea conditions.

(10) **Maximum Current**: Also use CHS Tide and Current Tables, CHS Sailing Directions, and, if necessary, local knowledge to complete this item. Currents require navigational adjustments and thus pose problems to mariners in themselves. The potential threat can be enhanced by other sea conditions (waves, winds, etc.). Currents also pose special problems when there is limited room for making turns, passing other vessels, etc.

(11) **Channel Siltation**: If there is sufficient siltation to warrant dredging or periodic relocation of aids to navigation markers, enter "yes" for this item. Local knowledge will be required to complete this item, but some indications of problems may be given in the published materials.

(12) **Distinctive Shoreline Features:** Use CHS Charts and Sailing Directions in conjunction with local knowledge to enter a "yes" or "no" as to whether or not shoreline features at the site are visually distinctive and/or show distinctively on radar. This information is used to judge the number and types of aids needed to assist the mariners by providing verification of position and warning of hazards.

2.5 Site Data Sheet Example

Attached (next page) is an example of a Site Data Sheet completed for Burnt Island, Newfoundland. The information was originally collected for the 1985 site analysis but has now been brought forward to the revised form.

Canadian Coast Guard / Garde côtière canadienne

Date: Dec /88

MARINE AIDS / AIDES À LA NAVIGATION
SITE DATA SHEET / DONNÉES D'EMPLACEMENT

DISTRICT	CHARTS / CARTES	SITE / EMPLACEMENT
St John's Nfld.	4635	Burnt Island

1 NAVIGATION SEASON / SAISON DE NAVIGATION

I Long-Range Commercial / Commerciaux de longue portée	
II Local Commercial / Commerciaux locaux	All year / À l'année longue
III Pleasure Craft / Bateaux de plaisance	

2 MAXIMUM SHIP SIZE / GRANDEUR DE NAVIRE MAXIMUM

	Gross Brut	Length Longueur	Beam Largeur	Draught Tirant d'eau
I Long-Range Commercial / Commerciaux de longue portée				
II Local Commercial / Commerciaux locaux	105	65'	20'	11'
III Pleasure Craft / Bateaux de plaisance		45'		

3 VOLUME OF TRAFFIC / VOLUME DE TRAFIC

	Number of users / Nombre de navires	Number of transits / Nombre de traversées
I Long-Range Commercial / Commerciaux de longue portée		
II Local Commercial / Commerciaux locaux	80 +	13,000
III Pleasure Craft / Bateaux de plaisance	12	24

4 NIGHT-TIME USAGE % USERS OPERATING IN DARKNESS / USAGE À LA NOIRCEUR % DE NAVIRES QUI CIRCULENT LA NUIT

I Long-Range Commercial / Commerciaux de longue portée	
II Local Commercial / Commerciaux locaux	100 %
III Pleasure Craft / Bateaux de plaisance	

		OUTER APPROACHES - APPROCHE EXTÉRIEURE OPEN WATER - EAUX LIBRES	INNER APPROACH - APPROCHE INTÉRIEURE CONFINED WATER - EAUX RESTEINTES
5 VISIBILITY % TIME VISIBILITY EQUAL TO OR GREATER THAN (nautical miles) (worst month of navigational season) July / VISIBILITÉ % DE TEMPS OÙ LA VISIBILITÉ EST ÉGALE OU SUPÉRIEURE À (milles marins) (mois le plus mauvais de la saison de navigation) Juillet	.5	86	86
	1.1	75	75
	2.2	65	65
	5.4	52	52
6 FREEZING SPRAY % OCCURRENCE (worst month of navigation season) / EMBRUNS VERGLAÇANTS % DE FRÉQUENCE (mois le plus mauvais de la saison de navigation)	Moderate / Modérés	19	19
	Heavy / Forts	10	10
	Severe / Dangereux	—	—
7 WIND SPEED % TIME WIND EXCEEDS (Knots) (navigation season) / VITESSE DU VENT % DE TEMPS OÙ LE VENT DÉPASSE (noeuds) (saison de navigation)	10	80	80
	20	43	43
	25	29	29
	30	17	17
	35	8	8
	40	3	3
8 WAVE HEIGHT % TIME WAVE HEIGHT EXCEEDS (Meters) (navigation season) / HAUTEUR DE VAGUE % DE TEMPS OÙ LA HAUTEUR DE VAGUE DÉPASSE (mètres) (saison de navigation)	1	77	77
	2	31	31
	3	14	14
	4	7	7
	5	3	3
	6	2	2
9 TIDE RANGE/FLUCTUATING WATER DEPTH (Feet) / AMPLITUDE DE MARÉE/VARIATIONS DE LA PROFONDEUR D'EAU (pieds)		6	6
10 MAXIMUM CURRENT (Knots) / COURANT MAXIMUM (noeuds)	Along track / Dans le sens de la route	1	1
	Across track / En travers de la route	1	1
11 CHANNEL SILTATION ? (Yes/No) / ENVASEMENT DU CHENAL ? (oui/non)		No/Non	No/Non
12 DISTINCTIVE SHORELINE FEATURES ? (Yes/No) / PARTICULARITÉS DISTINCTIVES DU RIVAGE (oui/non)	Visual / Visuelles	No/Non	No/Non
	Radar	No/Non	No/Non

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ENVIRONMENT CANADA / ENVIRONNEMENT CANADA
ATMOSPHERIC ENVIRONMENT SERVICE / SERVICE DE L'ENVIRONNEMENT ATMOSPHERIQUE
CANADIAN CLIMATE CENTRE / CENTRE CLIMATOLOGIQUE CANADIENNE

MARINE CLIMATOLOGICAL SUMMARIES / RESUMES CLIMATOLOGIQUES MARITIMES
PERCENTAGE FREQUENCY OF VISIBILITY AND GOOD SHIPPING WEATHER / FREQUENCE EN POURCENTAGE DE LA VISIBILITE ET DU TEMPS PROPICE A LA NAVIGATION

PERIOD: 1949 - 1984
PERIODE: 1949 A 1984

LOCATION: BURNT ISLANDS,GOD BAY, NFLD, NFLD REGION
LIEU: BURNT ISLANDS, GOD BAY, NFLD, NFLD REGION

	VISIBILITY (NAUTICAL MILES) / VISIBILITE (MILLES MARINS)						GOOD SHIPPING WEATHER / TEMPS PROPICE A LA NAVIGATION	
	<1/2	<1.1	<2.2	<5.4	≥5.4	NO. OF READINGS / NBRE DE LECTURES		NO. OF READINGS / NBRE DE LECTURES
JANUARY/JANVIER	5.4	9.6	15.0	31.3	68.8	240	50.6	239
FEBRUARY/FEVRIER	2.8	5.7	15.0	30.1	69.9	386	54.9	386
MARCH/MARS	3.4	6.4	11.9	25.1	74.9	438	64.1	437
APRIL/AVRIL	5.4	8.7	15.8	26.4	73.6	424	59.3	423
MAY/MAI	6.7	11.9	18.4	27.3	72.7	479	63.2	465
JUNE/JUIN	12.5	20.5	27.0	36.4	63.6	385	62.3	385
JULY/JUILLET	→ 14.4	→ 24.5	→ 35.3	→ 47.5	52.5	278	57.4	277
AUGUST/AOUT	8.0	14.0	20.1	31.4	68.6	264	67.6	262
SEPTEMBER/SEPTEMBRE	2.4	6.9	12.3	18.3	81.7	334	63.4	331
OCTOBER/OCTOBRE	2.0	5.6	11.9	21.0	79.0	252	55.9	247
NOVEMBER/NOVEMBRE	1.5	3.9	10.8	24.1	75.9	203	53.2	201
DECEMBER/DECEMBRE	1.8	7.2	13.2	18.6	81.4	167	47.9	167

GOOD SHIPPING WEATHER IS DEFINED AS VISIBILITY GREATER THAN 2 MILES AND WINDS LESS THAN 25 KNOTS
LE TEMPS PROPICE A LA NAVIGATION CORRESPOND A UNE VISIBILITE SUPERIEURE A 2 MILLES ET A DES VENTS DE MOINS DE 25 NOEUDS

ENVIRONMENT CANADA — ENVIRONNEMENT CANADA
ATMOSPHERIC ENVIRONMENT SERVICE — SERVICE DE L'ENVIRONNEMENT ATMOSPHERIQUE
CANADIAN CLIMATE CENTRE — CENTRE CLIMATOLOGIQUE CANADIENNE

MARINE CLIMATOLOGICAL SUMMARIES — RESUMES CLIMATOLOGIQUES MARITIMES
PERCENTAGE FREQUENCY DISTRIBUTION OF PRECIPITATION — DISTRIBUTION DE FREQUENCE DES PRECIPITATIONS EN POURCENTAGE
PERIOD: 1949 - 1984
PERIODE: 1949 A 1984

LOCATION: BURNT ISLANDS,GOD BAY, NFLD, NFLD REGION
LIEU: BURNT ISLANDS, GOD BAY, NFLD, NFLD REGION

	→ POTENTIAL ICING RATE DUE TO FREEZING SPRAY / INTENSITE EVENTUELLE DU GIVRAGE CAUSE PAR LES EMBRUNS						FREEZING PRECIPITATION / PRECIPITATIONS VERGLACANTES	FOG DEPOSITING RIME / BROUILLARD SE CONGELANT EN GIVRE BLANC	OBSERVATIONS WITH HAIL / OBSERVATIONS DE GRELE	OBSERVATIONS WITH THUNDER / OBSERVATIONS DE TONNERRE	NO. OF READINGS / NBRE DE LECTURES
	NONE / NULLE	LIGHT / FAIBLE	MODERATE / MODEREE	HEAVY / FORTE	SEVERE / DANGEREUSE	NO. OF READINGS / NBRE DE LECTURES					
JANUARY/JANVIER	71.2	22.0	6.8	0.0	0.0	59	1.3	0.0	0.0	0.0	227
FEBRUARY/FEVRIER	47.4	23.3	→19.0	→10.3	→ 0.0	116	1.9	0.0	0.0	0.0	372
MARCH/MARS	74.3	14.3	8.6	2.9	0.0	105	3.2	0.0	0.0	0.0	410
APRIL/AVRIL	93.1	6.9	0.0	0.0	0.0	102	0.1	0.0	0.0	0.0	405
MAY/MAI	100.0	0.0	0.0	0.0	0.0	199	0.2	0.0	0.0	0.0	465
JUNE/JUIN	100.0	0.0	0.0	0.0	0.0	188	0.0	0.0	0.0	0.0	383
JULY/JUILLET	100.0	0.0	0.0	0.0	0.0	69	0.0	0.0	0.0	0.0	273
AUGUST/AOUT	100.0	0.0	0.0	0.0	0.0	30	0.0	0.0	0.0	0.0	262
SEPTEMBER/SEPTEMBRE	100.0	0.0	0.0	0.0	0.0	42	0.0	0.0	0.0	0.0	328
OCTOBER/OCTOBRE	100.0	0.0	0.0	0.0	0.0	24	0.0	0.0	0.0	0.4	247
NOVEMBER/NOVEMBRE	100.0	0.0	0.0	0.0	0.0	28	0.0	0.0	0.0	0.0	193
DECEMBER/DECEMBRE	93.1	6.9	0.0	0.0	0.0	29	1.2	0.0	0.0	0.0	161

ATMOSPHERIC ENVIRONMENT SERVICE — ENVIRONMENT CANADA — ENVIRONNEMENT CANADA — SERVICE DE L'ENVIRONNEMENT ATMOSPHERIQUE
CANADIAN CLIMATE CENTRE — CENTRE CLIMATOLOGIQUE CANADIENNE

PERCENTAGE FREQUENCY OF WIND SPEED BY DIRECTION
FREQUENCE EN POURCENTAGE DE LA VITESSE DU VENT PAR DIRECTION

JAN 1 - DEC 31 — 1949 - 1984
1ER JANV AU 31 DEC — 1949 A 1984

LOCATION: BURNT ISLANDS,GOD BAY, NFLD, NFLD REGION
LIEU: BURNT ISLANDS, GOD BAY, NFLD, NFLD REGION

WIND SPEED (KNOTS) / VITESSE DU VENT (NOEUDS)	N	NE	E	SE	S	SW	W	NW	VAR	CALM / CALME	TOTAL FREQ. / FREQ. TOTALE	EXCEED. FREQ. / FREQ. DE DEPASS.
0- 4	0.1	0.4	0.5	0.4	0.5	0.3	0.4	0.3	0.2	4.1	7.3	100.0
5- 9	1.1	1.1	2.7	1.6	1.0	1.5	2.0	1.4	0.0	0.0	12.4	92.7
10- 14	1.4	1.3	3.8	2.3	1.5	1.6	3.4	2.5	0.0	0.0	17.9	80.3
15- 19	1.5	1.3	3.7	1.6	1.1	1.7	4.4	3.6	0.0	0.0	19.0	62.3
20- 24	1.0	0.7	3.1	1.0	0.7	1.0	3.2	3.6	0.0	0.0	14.8	43.4
25- 29	0.8	0.6	2.6	0.9	0.8	0.6	2.6	3.0	0.0	0.0	12.0	28.5
30- 34	0.6	0.4	1.9	0.7	0.4	0.4	1.7	2.5	0.0	0.0	8.0	16.5
35- 39	0.3	0.3	0.5	0.4	0.3	0.2	1.3	1.8	0.0	0.0	5.1	8.4
40- 44	0.2	0.0	0.4	0.1	0.1	0.0	0.6	0.7	0.0	0.0	2.1	3.4
45- 49	0.1	0.0	0.1	0.1	0.0	0.0	0.3	0.2	0.0	0.0	0.8	1.3
50- 54	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.3	0.5
55- 59	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2
60- 64	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
65- 69	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
70- 74	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
75- 79	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80- 84	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
85- 89	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90- 94	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
95- 99	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	7.0	6.1	18.9	9.6	6.4	7.8	20.1	19.7	0.2	4.1	100.0	

TOTAL NUMBER OF OBSERVATIONS 3871 NOMBRE TOTAL D'OBSERVATIONS
MEAN LATITUDE OF OBSERVATIONS 47.4N LATITUDE MOYENNE DES OBSERVATIONS
MEAN LONGITUDE OF OBSERVATIONS 59.2W LONGITUDE MOYENNE DES OBSERVATIONS

ENVIRONMENT CANADA — ENVIRONNEMENT CANADA
ATMOSPHERIC ENVIRONMENT SERVICE — SERVICE DE L'ENVIRONNEMENT ATMOSPHERIQUE
CANADIAN CLIMATE CENTRE — CENTRE CLIMATOLOGIQUE CANADIENNE

PERCENTAGE FREQUENCY OF COMBINED WAVE HEIGHT BY DIRECTION
FREQUENCE EN POURCENTAGE DE LA HAUTEUR COMBINEE DES VAGUES PAR DIRECTION

LOCATION: BURNT ISLANDS, GOD BAY, NFLD, NFLD REGION — JAN 1 - DEC 31 — 1949 - 1984
LIEU: BURNT ISLANDS, GOD BAY, NFLD, NFLD REGION — 1ER JANV AU 31 DEC — 1949 A 1984

WAVE HEIGHT (M) / HAUTEUR DES VAGUES (M)	N	NE	E	SE	S	SW	W	NW	IND	CALM / CALME	TOTAL FREQ. / FREQ. TOTALE	EXCEED. FREQ. / FREQ. DE DEPASS.
0.0- 0.9	1.9	1.1	5.1	1.9	1.5	2.3	5.1	3.8	0.0	0.6	23.2	100.0
1.0- 1.9	2.7	2.1	4.6	7.8	5.5	4.6	7.4	9.7	1.3	0.0	45.8	76.8
2.0- 2.9	0.2	0.4	1.9	2.7	2.1	2.3	2.9	3.6	0.4	0.0	16.7	31.0
3.0- 3.9	0.2	0.8	1.3	0.4	0.8	0.2	1.5	1.3	0.4	0.0	7.0	14.4
4.0- 4.9	0.6	0.0	0.4	0.4	0.6	0.6	0.6	1.1	0.0	0.0	4.0	7.4
5.0- 5.9	0.0	0.0	0.0	0.2	0.0	0.0	1.1	0.6	0.0	0.0	1.9	3.4
6.0- 6.9	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.2	1.5
7.0- 7.9	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.4	1.3
8.0- 8.9	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.4	0.8
9.0- 9.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
10.0-10.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
11.0-11.9	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4
12.0-12.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
13.0-13.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
14.0-14.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
15.0-	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.2	0.2
TOTAL	5.5	4.4	13.3	13.5	10.8	10.3	19.4	20.0	2.1	0.6	100.0	

TOTAL NUMBER OF OBSERVATIONS 474 NOMBRE TOTAL D'OBSERVATIONS
MEAN LATITUDE OF OBSERVATIONS 47.5N LATITUDE MOYENNE DES OBSERVATIONS
MEAN LONGITUDE OF OBSERVATIONS 58.9W LONGITUDE MOYENNE DES OBSERVATIONS

The first four items on this Site Data Sheet were completed for the site analysis using documentation in the files at the district office and local knowledge of the Coast Guard staff. The selection of data for the next four items (5 to 8) from the appended AES tables requires more explanation.

Item 5. **Visibility:** Data for this item were selected from the table "Percentage Frequency of Visibility and Good Shipping Weather." Note that the available data for this site covers inner and outer approaches and thus the figures recorded are identical in both columns. The attached table shows that July is the worst month of the year; that is, the month where restricted visibility occurs most often. Thus, the July figures were entered in the Site Data Sheet.

Item 6. **Freezing Spray:** The data for this item was selected from the table "Percentage Frequency Distribution of Precipitation." The table shows February to be the worst month and the data were entered accordingly.

Item 7. **Wind Speed:** Data for this item were selected from the table "Percentage Frequency of Wind Speed by Direction." The required data are summarized in the last column of the AES data table. Note that since the longest navigation season by type of vessel is "all year" for Category II, and this category also accounts for almost all the traffic, full-year data have been used. At other sites part year data might be required.

Item 8. **Wave Height:** Data for this item were selected from the table "Percentage Frequency of Combined Wave Height by Direction." Again, the required data are neatly summarized in the last column of the AES data table.

The final four items were completed for the site analysis using CHS Charts, Tide and Current Tables, and Sailing Directions, plus local knowledge.

2.6 Site Inventory Example

Attached are example Site Inventory Forms completed for the Burnt Island site in the fall of 1988.

Canadian Coast Guard / Garde côtière canadienne

MARINE AIDS SITE INVENTORY SUMMARY

AIDES À LA NAVIGATION SOMMAIRE DE L'INVENTAIRE DE L'EMPLACEMENT

District	Charts / Cartes	Site / Emplacement	Date
St John's Nfld.	4635	Burnt Island (outer approaches only)	Dec /85

Enter the total number at the site for each category / *Pour chaque catégorie, inscrire le nombre total à l'emplacement*

1. FIXED AIDS		**1. AIDES FIXES**
1.1 Major lights (≥ 10 n. miles nominal range)	1	1.1 Feux primaires (≥ 10 m. marins portée nominale)
1.2 Minor lights (<10 n. miles nominal range)		1.2 Feux secondaires (<10 m. marins portée nominale)
1.3 Ranges* : Lighted		1.3 Alignements* : Lumineux
: Unlighted		: Non lumineux
1.4 Day beacons		1.4 Balises de jour
1.5 Radar reflector beacons		1.5 Balises avec réflecteurs radar
1.6 Major fog signals (>1n.mile nom. range)	1	1.6 Signaux de brume primaires (>1 m. marin portée nom.)
1.7 Minor fog signals (≤ 1n. miles nom. range)		1.7 Signaux de brume secon. (≤1 m. marin portée nominale)
1.8 Racons on fixed structures		1.8 Racons sur ouvrages fixes
1.9 Others: ____________		1.9 Autres : ____________
(specify) ____________		(préciser) ____________
Sub-Total	2	**Total partiel**
2. FLOATING AIDS		**2. AIDES FLOTTANTES**
Lighted buoys:		Bouées lumineuses:
2.1 Large: Whistle (9'6" diam.; 6000kg)		2.1 Grandes: sifflet (9'6" diam.; 6000kg.)
2.2 Large: Bell or fog signal (9'6" diam.; 4400kg)	2	2.2 Grandes: cloche ou signal de brume (9'6" diam.; 4400kg.)
2.3 Medium (4' to 6' diam.; 1900-3000kg)		2.3 Moyennes: (4' à 6' diam.; 1900-3000kg.)
2.4 Small (< 4' diam.; 1000kg)		2.4 Petites: (< 4' diam.; 1000kg.)
Unlighted buoys:		Bouées non lumineuses:
2.5 Large (ice spars; > 600kg)	1	2.5 Grandes (espars d'hiver; > 600kg.)
2.6 Medium (175 to 600kg)		2.6 Moyennes (175 à 600kg.)
2.7 Small (< 175kg)		2.7 Petites (< 175kg.)
2.8 Racons on buoys		2.8 Racons sur bouées
2.9 Others: ____________		2.9 Autres: ____________
(specify) ____________		(préciser) ____________
Sub-Total	3	**Total partiel**
TOTAL NUMBER OF AIDS AT SITE	5	**NOMBRE TOTAL DES AIDES À L'EMPLACEMENT**

(* count ranges not structures or lights; pairs or single station count as one)

(* compter les alignements et non pas les ouvrages ou feux; une paire ou une station simple se compte comme un)

73-0116 (2/89)

Canadian Coast Guard / Garde côtière canadienne

MARINE AIDS SITE INVENTORY AND TECHNICAL DATA

District: St John's, Nfld. — Site: Burnt Island (outer approaches) — Charts: 4635 — Date: Dec /88

DESCRIPTION			Day-light Visual Range	Radar Range	LIGHT SIGNAL								SOUND SIGNAL			GENERAL HISTORY	
Aid Nº	General Category (see summary)	Particulars (name, type, size seasonality, etc.)	n. miles	n. miles	Lantern Type and Size	Rotation/ Flash Duration	Lens Type and Colour	Bulb Type	Bulb Voltage	Bulb Amps/ Watts	Candelas	Nominal Range n. miles	Horn db	Horn Hz	Nominal Range n. miles	Year Established	Circumstances, etc.
Q 34	2.2 Large Bell Buoy	"Bad Neighbour Shoal" 9'6" Bell - seasonal	2.4	7	200 mm Seagull	.5 sec 51	Red	N/A	12 V	0.77 amp	77	4	-	-	0.5	1964	Marks Bad Neighbour Shoal for Coastal traffic
QB1	2.2 Large Bell Buoy	"Burnt Island" 9'6" Bell - seasonal	3.4	7	200 mm Seagull	.5 sec 51	Green	N/A	12 V	0.77 amp	33	4	-		0.5	1984	Marks Twin Rocks, inbound channel
QB1	2.5 Large Ice Spar	3'3" DIA Sq. ft (current) - winter	1.5	2.5	-	-	-		-	-			-		-	1984	winter replacement for QB1
LL 156	1.1 Major Light	Columbier Island	5	N/A	DCB 10	6 rpm	White	[illegible]	N/A	[illegible]	[illegible]	15	-	-	-	1929	Landfall entrance to Burnt Island
LL 156	1.6 Major Fog Signal	Columbier Island AP: 1000ELG 300-02	N/A	N/A	-			-				-	143	300	2.0	1929	Upgraded 1973, 12 mos operation.

73 0117 (1189) — Français au verso

3. PRELIMINARY HAZARD IDENTIFICATION AND THREAT RATING

3.1 General Considerations

Having completed the Site Inventory Sheets and the Site Data Sheet, the next major task for the review and design of Short-Range Marine Aids systems is the preliminary site review and rating of specific types of threats to the safe and expeditious movement of marine traffic. This initial rating considers each threat individually. Only after threats have been examined in this way can the interactive effects (e.g. of fog and wind and waves together) be considered and a final rating be given to composite threats in order to identify mariners' needs for information and assistance from aids or other sources. The procedures for rating composite threats and identifying navigational needs will be outlined in the next chapter.

In the outer approaches, the navigational needs of mariners vary primarily according to the equipment carried and the skill and knowledge of the operator -- i.e. by Category of Vessel. Thus ratings have to be done separately for each category of the vessels that navigates in the area. What constitutes a "threat", however, is more dependent on the vessel draught, its ability to stop and/or turn, and its ability to cope with wind and waves. In general, the larger the vessel the more depth and distance it needs to manoeuvre, and thus the more likely it is that hazards and conditions will pose threats for which the mariner will have to be warned. Thus, the primary threat ratings are usually based on the largest vessels in each category. For certain types of threats, however, other types of vessels within the category are more adversely affected and therefore these types must be the basis for rating the threat.

This stage of the review and design process involves the completion of a Preliminary Threat Rating Form (see following page) using the charts for the site and the Site Data Sheet. This is done in a step-by-step fashion by first noting relevant vessel types, then identifying potential hazards and likely traffic paths, and, finally, identifying relevant ratings one by one for nine specific types of threats.

This Preliminary Threat Rating process was developed in consultation with experienced mariners. The benchmarks used to determine the degree of threat are based upon the inputs from senior Coast Guard Fleet officers, commercial mariners and pilots, and fishing and pleasure craft groups. Continued refinement of this form and the benchmarks is expected as more input is obtained in the future.

Canadian Coast Guard / Garde côtière canadienne

MARINE AIDS
PRELIMINARY THREAT RATING

District ....
Charts ....
Site ....
Date ....

Vessel Category	SIZE AND TYPE OF VESSELS: Length (feet)	Gross Tonnage	Beam (feet)	Draught (feet)	General Types	SUBMERGED HAZARDS: Non threatening under keel clearance (feet)	Minimum depth allowance metres ☐ or feet ☐	TYPES OF THREATS (Column A - Significant, Column B - Highly Significant): Distance from hazard (feet) A	B	Distance from other vessel when passing (feet) A	B	Minimum channel width (feet) A	B	Angle of turn in channel (degrees) A	B	Wind speed (knots) A	B	Wave height (metres) A	B	Current speed: Along track (knots) A	B	Current speed: Across track (knots) A	B	Visibility (nautical miles) A	B
◯	1000 +	80,000-300,000	140'-200'	54'-80'	Ocean-going tanker, ore and bulk carrier	15'		1000	800	300	200	1000	800	15	20	20	30	3	6	2	3	1	2	3	2
◯	1000 +	32,000-37,000	105'	26'-40'	Laker, bulk freighter and self unloader (American)	15'		1000	800	300	200	1000	800	15	20	20	30	3	6	2	3	1	2	3	2
◯	800-1000	30,000-100,000	85'-175'	26'-64'	Ocean-going tanker, ore and bulk carrier	15'		1000	800	300	200	1000	800	15	20	20	30	3	6	2	3	1	2	3	2
◯	730-1000	12,000-28,000	70'-105'	26'-40'	Laker, bulk freighter and self unloader	15'		600	400	300	200	1000	800	20	30	10	30	1.5	3	2	4	1	3	3	2
◯	630-800	10,000-60,000	60'-140'	20'-54'	Tanker, ore and bulk carrier, general cargo	15'		600	400	200	100	1000	800	20	30	10	20	1.5	3	4	7	1	3	3	1.5
◯	700-730	11,000-25,000	62'-78'	21'-35'	Laker, bulk freighter and self unloader	15'		600	400	200	100	1000	500	20	30	10	20	1	2.5	4	7	1	2	3	1
◯	550-630	8,000-30,000	55'-105'	20'-42'	Tanker, ore and bulk carrier, general cargo	15'		600	400	200	100	800	500	20	35	20	30	1	2.5	5	7	1	3	2	1
◯	300-550	2,500-20,000	43'-105'	16'-38'	Tanker, ore and bulk carrier, general cargo	15'		500	300	200	100	600	400	20	35	20	30	1	2.5	5	7	1	3	2	1
◯	300-600	2,500-13,000	56'-90'	13'-20'	Car ferry	15'		1000	600	400	300	600	400	20	35	20	30	1	2.5	5	7	1	3	3	1.5
◯	200-300	10-1,500	12'-70'	2'-8'	Car ferry	10'		500	300	300	100	400	200	30	45	25	30	1	2.5	3	6	2	4	2	1
◯	200-300	2,000-3,500	23'-65'	8'-20'	Tanker, bulk freighter, self unloader, fish factory	15'		400	300	200	100	600	200	30	40	25	30	1	2.5	5	7	1	3	2	1
◯	200-250	2,000-3,000	40'-60'	8'-20'	Small tanker, general cargo, fishing (long liner)	10'		300	200	200	100	400	200	30	45	25	30	1	2.5	3	6	1.5	3	2	1
◯	150-200	1,500-2,500	30'-50'	8'-15'	Small tanker, general cargo, fishing (long liner)	10'		300	200	200	100	300	200	30	45	25	30	1	2	3	6	1	2	2	1
◯	80-150	200-800	12'-50'	4'-15'	Small tanker, general cargo, fishing (dragger, long liner)	10'		300	150	200	100	300	200	30	45	20	30	1	2	3	4	1	2	2	1
◯	65-100	40-250	13'-28'	5'-15'	Tugs, small draggers, long liners, pleasure craft	4'		200	100	100	50	300	200	30	45	20	30	1	2	3	4	1	2	1.5	1
◯	45-65	20-180	8'-16'	4'-15'	Tugs, work boats, small draggers, inshore long liners pleasure craft	4'		200	100	100	50	300	200	30	45	20	30	1	2	3	4	1	2	1.5	1
◯	32-45	8-50	4'-14'	3'-8'	Tugs, work boats, fishing (Cape Islanders, trollers), pleasure craft	4'		200	100	100	50	200	100	30	50	20	30	1	2	3	4	2	3	1.5	1
◯	25-35	4-20	4'-11'	3'-5'	Tugs, work boats, fishing trollers, pleasure craft	4'		100	75	50	30	100	50	40	60	20	25	1	1.5	4	5	2	4	1	0.5
◯	12-25	1-7	3'-8'	2'-4'	Tugs, work boats, inshore fishing, pleasure craft	4'		100	50	40	20	100	50	50	70	10	20	1	1.5	4	5	3	5	1	0.5
◯	300	10-1,000	12'-80'	2'-5'	Athabasca River tugs and barges	1.5'		75	25	200	100	150	100	40	60	20	40	N/A	N/A	5	7	4	6	1	0.5
◯	up to 950	10,000	160'	6'	Mackenzie River tugs and barges - upstream	3'		100	50	400	200	300	250	90	120	30	40	1	1.5	5	7	2	3	1	0.5
◯	up to 950	10,000	160'	6'	Mackenzie River tugs and barges - downstream	5'		200	100	400	200	400	300	40	60	25	35	1	1.5	5	7	1	2	2	1

Français au verso

3.2 Specifying Vessel Types for Ratings

Refer to Item 2 "Maximum Ship Size" on the Site Data Sheet (p. 2-10). Apply this data to identify the equivalent type of vessel on the Preliminary Threat Rating Form for each relevant category of vessel. Indicate these rows on this form by noting the vessel category in the left-most column and by highlighting the full line in some way (e.g., underlining or circling in colour, highlighter). Where specific vessel draughts have been given on the Site Data Sheet, Item 2, put these figures in the relevant space under Draught on the Preliminary Threat Rating Form. Also, at this step note the district, chart numbers, and common name of the site in the space provided at the top right of the Preliminary Threat Rating Form.

3.3 Denoting Potential Hazards and Traffic Paths

3.3.1 Minimum Depth by Type of Vessel

Calculate the minimum depth required for the type of vessel identified (highlighted) for each category on the Preliminary Threat Rating Form by summing (combining):

(a) vessel draught; that is, either the specific draught noted from the Site Data Sheet or the deepest draught specified on the applicable highlighted line;

(b) the highest wave height which is exceeded 5% or more of the time, from the Site Data Sheet, Item 8;

(c) the under-keel clearance required for that type of vessel, as shown on the Preliminary Threat Rating Form under Submerged Hazards: Non-Threatening Under Keel Clearance. (Note that this is the amount of clearance required before aids are provided and hazards marked. Once aids are provided and hazards have been marked, vessels may proceed safely with less clearance; e.g., in the St. Lawrence Seaway, vessels may move with as little as one foot of under-keel clearance.)

Convert this sum to feet or to metres, according to the scale used to measure depth on the chart, and enter these figures in the relevant space under "Minimum Depth Allowance".

Note that the effects of tides are not normally included in this calculation because CHS charts and water depths are based on low tides and minimum water. However, in any tidal area where depths are not based on minimum water level, tidal action will have to be included in this calculation. Also note that very high tides may create submerged hazards.

3.3.2 Potential Hazards

Now go to the largest scale CHS Chart for the area. Note the potential hazards or line of hazard where the depth is less than the specified minimums.

3.3.3 Traffic Paths

Taking into account these potential hazards, and utilizing any charted tracks plus local knowledge of vessel routes, plot the likely routes on the working copy (or photocopy) of the chart. Note that this can be different for the three categories because of different depth requirements and different patterns of usage (e.g., fishermen and pleasure-craft users may go further upstream than large commercial vessels; inshore fishermen may spread out at the harbour entrance while longliners will tend to go directly to particular fishing grounds).

3.4 Preliminary Rating of Threats

By using the marked chart, the Site Data Sheet and the Preliminary Threat Rating Form, it is possible to identify the appropriate individual ratings of threats. Note that at this stage the ratings are prescriptive and mechanical. The specified values for determining at what point a situation or set of conditions should be rated "Significant Threat" or "Highly Significant Threat" have been arrived at after extensive consultation with knowledgeable navigators. These are benchmarks to be used for preliminary ratings. These preliminary ratings, together with professional judgement and local knowledge of unique aspects of the site, including interactive effects between the types of threats, will be used at the next stage of the process to establish the final ratings for composite threats.

It should also be noted that the purpose of these ratings is to help identify situations where short-range marine aids are needed and the types needed, not to define completely unsafe "no go" conditions. Such situation will vary from vessel to vessel and mariner to mariner. Determining what contributes a "no go" situation is a decision that must be left to the informed judgement of the mariners or the judgement of those controlling and managing waterways (e.g., the St. Lawrence Seaway Authority).

3.4.1 Distance From Hazard

Following the likely traffic paths drawn on the chart, determine whether, for each type of category of vessel, the largest is likely to pass within the threatening range of potential hazards specified on the Preliminary Threat Rating Form; that is, for the highlighted line for each category of vessel, determine if the normal path will take it within the distance shown in column B ("Highly Significant") or, if not, within the distance shown in column A ("Significant"). When this normal path can take the vessel within the distance from the hazard specified in column B, circle this value to denote a "Highly Significant" threat rating for "Distance from Hazard" for this category of vessel. If not within the distance specified in column B, but within the distance specified in column A, circle the line value in column A to denote a "Significant" threat rating for "Distance from Hazard" for this category of vessel.

3.4.2 Distance From Other Vessel When Passing

Use local knowledge to determine whether or not there is two-way or multi-directional traffic at the site, and if so, the types of vessels involved. Where this is the case, examine the chart to note any segments of the channel where passing room is restricted. Estimate the likely minimum passing distance for each relevant category of vessel. Determine whether this falls within the threatening distances as set out in the Form per the highlighted line for each relevant category of vessels. Where this occurs, circle the relevant row value in column B or in column A, as specified in 3.4.1.

Exception: Note that car ferries require more passing room than other larger commercial vessels. If a car ferry uses the site and is not the "largest vessel" of its category (i.e. the denoted row for the category), the threat has not been given a "B" rating for this category, and the passing room is less than the minimum specified for car ferries in column B, circle this value as the rating. Alternatively, circle the car ferry "A" rating, if appropriate.

3.4.3 Minimum Channel Width

Employing the chart and local knowledge of the types of vessels that use different segments of the channel, note any places where the minimum channel width is less than the marked row values. Circle any applicable values to denote the threat rating level.

3.4.4 Angle of Turn in Channel

Employing the chart and local knowledge of the types of vessels using different segments of the channel, note any places where a required turn is greater than the values shown in the marked vessel category rows for columns B or A. Circle any applicable values to denote the threat rating level.

3.4.5 Wind Speed

When the wind is from a direction and at a speed that adversely affects the operation of the vessel and its ability to manoeuvre (e.g., wind causing a vessel to crab; that is, move at an angle to its heading to maintain course) more than 10% of the time, it is considered to be a significant threat.

Turning to the Site Data Sheet (p. 2-10), Item 7, note the maximum wind speed that is exceeded more than 10% of the time. Turning to the column "Wind Speed" on the Preliminary Threat Rating Form, note if this is equal to or greater than any of the values under column B ("Highly Significant") in the denoted rows or if not B, column A ("Significant"); then circle such values to denote applicable ratings. Note that where separate data have been received on the outer and inner approaches of the site, different ratings may be given to each of these items and must be labelled as such on the Preliminary Threat Rating Form.

<u>Exception</u>: Tolerance of wind speed is not a smooth function of vessel size. In many cases smaller vessels are less tolerant than larger ones. If this threat has not been rated a "B" by the preceding procedure, consider smaller vessels within the category that use the site and note if a "B" rating is appropriate for them. If so, circle the value on this line in under column B. If not, and the threat has not been rated "A" for the category, follow the same procedure to determine if an "A" rating applies, and circle relevant values.

3.4.6 Wave Height

The benchmarks under this threat relate only to the problems of keeping the vessel on course and manoeuvring. Very high waves can also make it very difficult to see buoys. This latter problem will have to be taken into account in the operational analysis when calculating the visual range of buoys and the possible need for other aids.

When waves are high enough to adversely affect the operation and manoeuvrability of the vessels more than 10% of the time, this is a "Significant" or "Highly Significant" threat. Note that for this type of threat, the smaller the vessel the more likely it is that wave height will cause a problem.

On the Site Data Sheet note the wave heights that are exceeded 10% or more of the time. Here again separate data for the inner and outer approaches can result in different ratings for the two parts of the site, and thus ratings must be labelled accordingly. On the Preliminary Threat Rating Form, under the heading Wave Height, for each category of vessel start at the marked row under column B and follow down the column for other sizes of users in the same category to see if any of the values are exceeded more than 10% of the time as shown on the Site Data Sheet (Note that the AES data transposed to the Site Data Sheet is in 1 metre categories while some of the values on the Form are to a half a metre; thus, interpolation may be required for this item.) Circle the first value, if any, where this is the case. If "B" is not an appropriate rating, follow the same procedure for column A. This procedure will have to be repeated for outer and inner approaches where the site data is distinct.

3.4.7 Current: Along Track and Across Track

Current also affects the operations and manoeuvrability of vessels. Like wind, it can cause crabbing. It also affects the time and distance required for stopping and turning. Although across-track current has a more adverse effect, the along track current can also cause problems and force vessels toward hazards. Because these effects are direct and not mitigated by the momentum of the vessel, even relatively slow currents are a threat.

Applying the current velocities noted on the Site Data Sheet, determine if the along track or across track maximum current speed is a "Significant" or "Highly Significant" threat in the outer or inner approaches for any of the user categories. If so, circle the row values to note the appropriate rating. Note that in some cases smaller vessels are less able than larger vessels to cope with current. Therefore, both the designated row and the rows below it for smaller vessels will have to be scanned, in accordance with procedures noted in previous sections, to determine the appropriate values to circle to denote the ratings applicable for that category.

3.4.8 Visibility

It must be noted that "Visibility" and "Darkness" are considered to be distinct factors or problems when determining requirements for aids. The term "Visibility" refers to the impacts of weather (fog, mist, snow, rain, etc.) and environmental factors (forest fires, smog, etc.). Visual sightings are a primary means of navigation, of determining the location of the vessel and hazards. Reduced visibility means less certainty of the position of the vessel and less warning of approaching hazards. In general, the larger the vessel the more warning required and therefore the longer the range of visibility needed. In general this threat is considered to be "Significant" or "Highly Significant" where visibility is reduced below the benchmarks shown in the table 10% or more of the time during any month of the navigation season (i.e., during the "worst" month).

Comparing the Site Data Sheet and the Preliminary Threat Rating Form note that while the AES data categories used on the Site Data Sheet are visibility less than .5, 1.1, 2.2, and 5.4 nautical miles, the data provided by users and incorporated in the Form uses categories of visibility less than .5, 1, 1.5, 2 and 3 nautical miles. Thus interpolation is required when using the data on the Site Data Sheet to identify preliminary ratings for "Visibility".

To determine the appropriate ratings for this threat, note the benchmark distances (visibility requirements) on the Preliminary Threat Rating Form that denote "Significant" and "Highly Significant" threats for each relevant category of users. From the Site Data Sheet, establish whether the visibility is less than any of these relevant benchmarks more than 10% of the time. If so, circle the applicable ratings. Where appropriate repeat this for inner and outer approaches and label the results accordingly.

3.5 Preliminary Threat Rating Example

Figure 1 (next page) is an example of a chart marked with traffic paths. It was prepared by Acres International Limited as part of the Newfoundland Lightstation Standardization Project to review Colombier Island Lightstation. For our purposes it is important because it illustrates Burnt Island site. Unfortunately, it also illustrates a common problem. The scale is too small and thus the chart can only be used to review the outer approaches; that is, up to the landfall point of Colombier Island Lightstation.

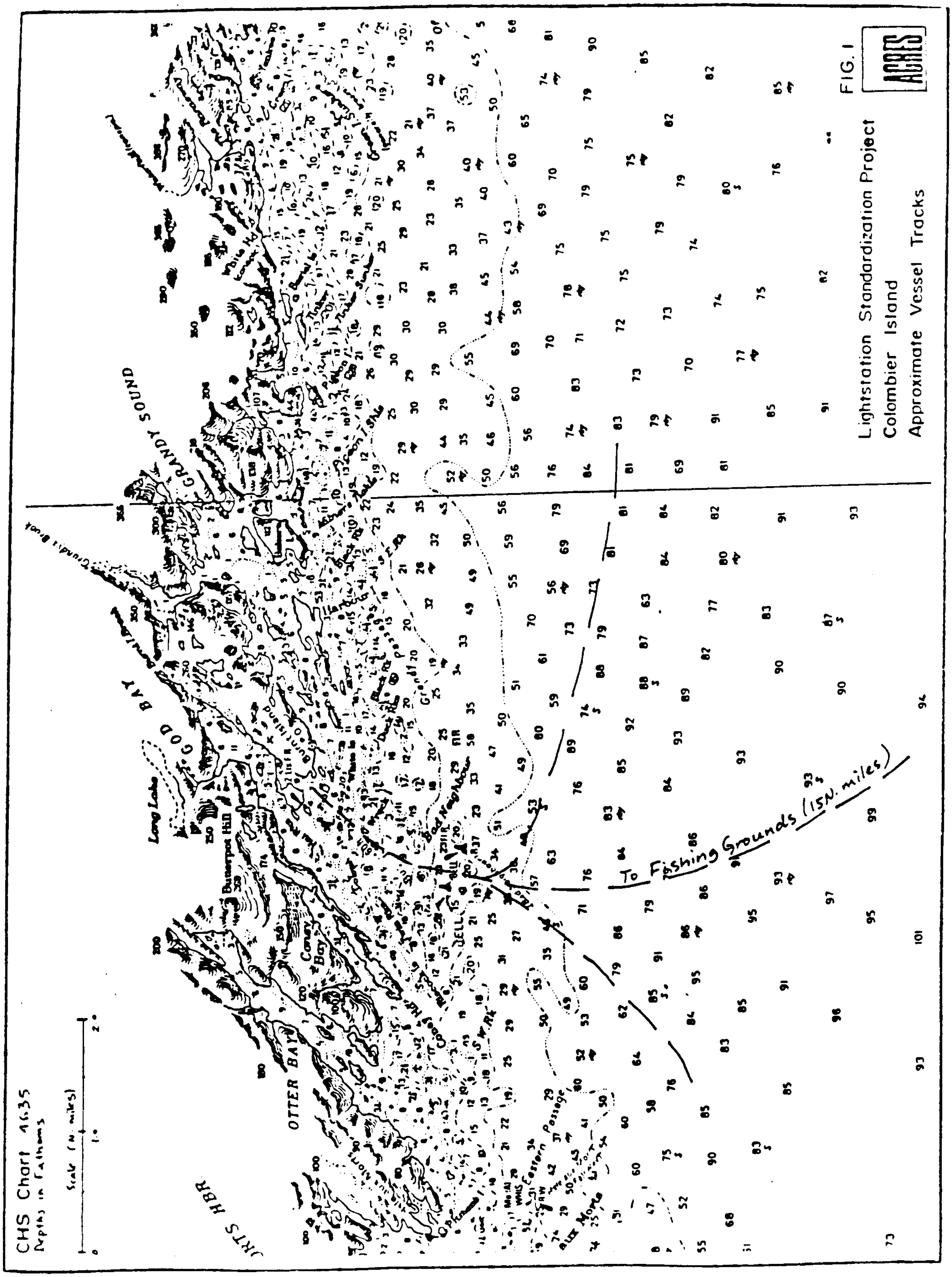

FIG. 1
Lightstation Standardization Project
Colombier Island
Approximate Vessel Tracks

Canadian Coast Guard / Garde côtière canadienne

MARINE AIDS
PRELIMINARY THREAT RATING

District: St. John's, Nfld
Charts: 4635
Site: Burnt Island
Date: Dec./88

Vessel Category	SIZE AND TYPE OF VESSELS: Length (feet)	Gross Tonnage	Beam (feet)	Draught (feet)		General Types	SUBMERGED HAZARDS: Non-threatening under keel clearance (feet)	Minimum depth allowance metres ☐ or feet ☐	TYPES OF THREATS (Column A - Significant, Column B - Highly Significant): Distance from hazard (feet) A	B	Distance from other vessel when passing (feet) A	B	Minimum channel width (feet) A	B	Angle of turn in channel (degrees) A	B	Wind speed (knots) A	B	Wave height (metres) A	B	Current speed: Along track (knots) A	B	Across track (knots) A	B	Visibility (nautical miles) A	B
	1000 +	80,000-300,000	140'-200'	54'-80'		Ocean-going tanker, ore and bulk carrier	15'		1000	800	300	200	1000	800	15	20	20	30	3	6	2	3	1	2	3	2
	1000 +	32,000-37,000	105'	26'-40'		Laker, bulk freighter and self unloader (American)	15'		1000	800	300	200	1000	800	15	20	20	30	3	6	2	3	1	2	3	2
	800-1000	30,000-100,000	85'-175'	26'-64'		Ocean-going tanker, ore and bulk carrier	15'		1000	800	300	200	1000	800	15	20	20	30	3	6	2	3	1	2	3	2
	730-1000	12,000-28,000	70'-105'	26'-40'		Laker, bulk freighter and self unloader	15'		600	400	300	200	1000	800	20	30	10	30	1.5	3	2	4	1	3	3	2
	630-800	10,000-80,000	60'-140'	20'-54'		Tanker, ore and bulk carrier, general cargo	15'		600	400	200	100	1000	800	20	30	10	20	1.5	3	4	7	1	3	3	1.5
	700-730	11,000-25,000	62'-78'	21'-35'		Laker, bulk freighter and self unloader	15'		600	400	200	100	1000	500	20	30	10	20	1	2.5	4	7	1	2	3	1
	550-630	8,000-30,000	55'-105'	20'-42'		Tanker, ore and bulk carrier, general cargo	15'		600	400	200	100	800	500	20	35	20	30	1	2.5	5	7	1	3	2	1
	300-550	2,500-20,000	43'-105'	16'-38'		Tanker, ore and bulk carrier, general cargo	15'		500	300	200	100	600	400	20	35	20	30	1	2.5	5	7	1	3	2	1
	300-800	2,500-13,000	56'-80'	13'-20'		Car ferry	15'		1000	600	400	300	600	400	20	35	20	30	1	2.5	5	7	1	3	3	1.5
	200-300	10-1,500	12'-70'	2'-8'		Car ferry	10'		500	300	300	100	400	200	30	45	25	30	1	2.5	3	8	2	4	2	1
	200-300	2,000-3,500	23'-65'	9'-20'		Tanker, bulk freighter, self unloader, fish factory	15'		400	300	200	100	600	200	30	40	25	30	1	2.5	5	7	1	3	2	1
	200-250	2,000-3,000	40'-60'	8'-20'		Small tanker, general cargo, fishing (long liner)	10'		300	200	200	100	400	200	30	45	25	30	1	2.5	3	6	1.5	3	2	1
	150-200	1,500-2,500	30'-50'	6'-15'		Small tanker, general cargo, fishing (long liner)	10'		300	200	200	100	300	200	30	45	25	30	1	2	3	6	1	2	2	1
	80-150	200-800	12'-50'	4'-15'		Small tanker, general cargo, fishing (dragger, long liner)	10'		300	150	200	100	300	200	30	45	20	30	1	2	3	4	1	2	2	1
(I)	65-100	60-250	12'-28'	5'-15'	11'	Tugs, small draggers, long liners, pleasure craft	4'	28'	200	100	(100)	50	300	200	30	45	20	(30)	1	(2)	3	4	(1)	2	1.5	(1)
	45-65	20-100	9'-16'	4'-15'		Tugs, work boats, small draggers, inshore long liners pleasure craft	4'		200	100	100	50	300	200	30	45	20	30	1	2	3	4	1	2	1.5	1
(III)	32-45	8-50	4'-14'	3'-9'	7'	Tugs, work boats, fishing (Cape Islanders, trollers), pleasure craft	4'	26'	200	100	(100)	50	200	100	30	50	20	(30)	1	(2)	3	4	2	3	1.5	(1)
	25-35	4-20	4'-11'	3'-5'		Tugs, work boats, fishing trollers, pleasure craft	4'		100	75	50	30	100	50	40	60	20	25	1	1.5	4	5	2	4	1	0.5
	12-25	1-7	3'-8'	2'-4'		Tugs, work boats, inshore fishing, pleasure craft	4'		100	50	40	20	100	50	50	70	10	20	1	1.5	4	5	3	5	1	0.5
	300	10-1,000	12'-80'	2'-5'		Athabasca River tugs and barges	1.5'		75	25	200	100	150	100	40	60	20	40	NA	NA	5	7	4	6	1	0.5
	up to 950	10,000	170'	6'		Mackenzie River tugs and barges - upstream	3'		100	50	400	200	300	250	90	120	30	40	1	1.5	5	7	2	3	1	0.5
	up to 950	10,000	160'	6		Mackenzie River tugs and barges - downstream	5'		200	100	400	200	400	300	40	60	25	35	1	1.5	5	7	1	2	2	1

71-0118 (1-89)

Français au verso

Canadian Coast Guard / Garde côtière canadienne

Date: Dec. /88

MARINE AIDS / AIDES À LA NAVIGATION
SITE DATA SHEET / DONNÉES D'EMPLACEMENT

DISTRICT	CHARTS / CARTES	SITE / EMPLACEMENT
St John's Nfld.	4635	Burnt Island

1 NAVIGATION SEASON / SAISON DE NAVIGATION

Long-Range Commercial	I		I	Commerciaux de longue portée
Local Commercial	II	All year / À l'année longue	II	Commerciaux locaux
Pleasure Craft	III		III	Bateaux de plaisance

2 MAXIMUM SHIP SIZE / GRANDEUR DE NAVIRE MAXIMUM

		Gross / Brut	Length / Longueur	Beam / Largeur	Draught / Tirant d'eau		
Long-Range Commercial	I					I	Commerciaux de longue portée
Local Commercial	II	105	65'	20'	11'	II	Commerciaux locaux
Pleasure Craft	III		45'			III	Bateaux de plaisance

3 VOLUME OF TRAFFIC / VOLUME DE TRAFIC

		Number of users / Nombre de navires	Number of transits / Nombre de traversées		
Long-Range Commercial	I			I	Commerciaux de longue portée
Local Commercial	II	80 +	13,000	II	Commerciaux locaux
Pleasure Craft	III	12	24	III	Bateaux de plaisance

4 NIGHT-TIME USAGE % USERS OPERATING IN DARKNESS / USAGE À LA NOIRCEUR % DE NAVIRES QUI CIRCULENT LA NUIT

Long-Range Commercial	I		I	Commerciaux de longue portée
Local Commercial	II	100 %	II	Commerciaux locaux
Pleasure Craft	III		III	Bateaux de plaisance

Item		OUTER APPROACHES - APPROCHE EXTÉRIEURE OPEN WATER - EAUX LIBRES	INNER APPROACH - APPROCHE INTÉRIEURE CONFINED WATER - EAUX RESTREINTES		Article
5 VISIBILITY % TIME VISIBILITY EQUAL TO OR GREATER THAN (nautical miles) (worst month of navigational season) July	.5	86	86	.5	VISIBILITÉ % DE TEMPS OÙ LA VISIBILITÉ EST ÉGALE OU SUPÉRIEURE À (milles marins) (mois le plus mauvais de la saison de navigation) Juillet
	1.1	75	75	1.1	
	2.2	65	65	2.2	
	5.4	52	52	5.4	
6 FREEZING SPRAY % OCCURRENCE (worst month of navigation season)	Moderate	19	19	Modéré	EMBRUNS VERGLAÇANTS % DE FRÉQUENCE (mois le plus mauvais de la saison de navigation)
	Heavy	10	10	Forte	
	Severe	—	—	Dangereuse	
7 WIND SPEED % TIME WIND EXCEEDS (Knots) (navigation season)	10	80	80	10	VITESSE DU VENT % DE TEMPS OÙ LE VENT DÉPASSE (noeuds) (saison de navigation)
	20	43	43	20	
	25	29	29	25	
	30	17	17	30	
	35	8	8	35	
	40	3	3	40	
8 WAVE HEIGHT % TIME WAVE HEIGHT EXCEEDS (Meters) (navigation season)	1	77	77	1	HAUTEUR DE VAGUE % DE TEMPS OÙ LA HAUTEUR DE VAGUE DÉPASSE (mètres) (saison de navigation)
	2	31	31	2	
	3	14	14	3	
	4	7	7	4	
	5	3	3	5	
	6	2	2	6	
9 TIDE RANGE/FLUCTUATING WATER DEPTH (Feet)		6	6		AMPLITUDE DE MARÉE/VARIATIONS DE LA PROFONDEUR D'EAU (pieds)
10 MAXIMUM CURRENT (Knots)	Along track	1	1	Dans le sens de la route	COURANT MAXIMUM (noeuds)
	Across track	1	1	En travers de la route	
11 CHANNEL SILTATION ? (Yes/No)		No / Non	No / Non		ENVASEMENT DU CHENAL ? (oui/non)
12 DISTINCTIVE SHORELINE FEATURES ? (Yes/No)	Visual	No / Non	No / Non	Visuelles	PARTICULARITÉS DISTINCTIVES DU RIVAGE (oui/non)
	Radar	No / Non	No / Non	Radar	

73-0115 (2/89)

Following this is a completed Preliminary Threat Rating Form for this site and the completed Site Data Sheet repeated from the final section of the previous chapter.

The first step in completing this form was to identify the rows representing the largest vessel in each of the two relevant user categories. Note that as shown on the Site Data Sheet, none of the users qualify as Category I vessels (although they might do so if they were properly certified). The largest Category II vessel using the site falls in the 65' to 100' class and thus this is the designated line for this category. The maximum draft can be specified at 11'. The largest pleasure craft using the site is in the 32' to 45' class. Since no maximum draught is given for the pleasure craft, the maximum depth already shown in the form is used to determine Minimum Depth Allowance.

The next step is to calculate these Depth Allowance figures for the two relevant vessel categories.

For Category II this is 11' (Draught) plus 13' (4 meters, the Wave Height exceeded 5% of the time) plus 4' (Non-Threatening Under Keel Clearance) which equals 28 feet. For Category III this is, similarly, (9'+13'+4') which equals 26 feet.

The next step is to evaluate "Distance From Hazard". As can be seen there are a large number of hazards at this site (rocks and shoals). The traffic path passes very close to a rock and a two fathom (12') shoal about 3/4 mile and 1/2 mile directly off the point of Burnt Island. While on such a small scale chart it is difficult to be sure of the distance, this appears to be less than 100', which means that this threat is "Highly Significant" for both vessel categories.

The next threats to evaluate are "Distance From Other Vessel When Passing" and "Minimum Channel Width". The "Minimum Channel Width" appears to be about 600' between the two fathom shoal noted above and a three fathom shoal on the other side of the path, which is sufficient for both categories and also allows sufficient passing room. Thus, neither of these two aspects provide serious threats for either of the categories.

The next threat to evaluate is "Angle of Turn in Channel". This is exceedingly difficult to evaluate with such a small scale chart. However there does not appear to be any sharp turns in the channel and thus there does not appear to be any rated threat here.

The next potential threat is "Wind Speed". The wind exceeds 30 knots 17% of the time (considerably more than 10%) which means that this threat is "Highly Significant" for both vessel categories.

The next is "Wave Height". Waves of 2 metres or more 10% of the time would make this a "Highly Significant" threat for the largest vessels of both categories and 1.5 metres is sufficient to get this rating for some of the smaller vessels in

Category II and Category III that use the site. The waves here are 3 metres or more 14% of the time. This threat thus falls into the "Highly Significant" category, and is even more critical than this rating suggests.

The next type of threat to evaluate is the current. The maximum current both along and across the track is one knot. This, however, is sufficient to rate the across-track current as "Significant" for Category II users.

The final type of threat to be given a preliminary rating here is "Visibility". As shown on the Site Data Sheet, visibility at this site is 1.1 nautical mile or more only 75% of the time in the worst month of the year (July). As shown on the Preliminary Threat Rating Form, for both vessel categories if visibility is less than 1 mile more than 10% of the time in the worst month, this qualifies as a "Highly Significant" threat. Thus visibility at this site is very definitely a severe problem.

4. NEEDS ANALYSIS

4.1 General Considerations

Having rated individual threats to safe and expeditious movement of marine traffic, the next set of tasks for design and review of Short-Range Marine Aids systems involves: rating composite threats (i.e., taking into account interactive effects and unique features of the site); identifying related needs; noting to what extent these needs are met by existing local means and natural features; and, where there is an aids system already in existence, comparing these needs with what has been provided. These tasks prepare the ground for the next stage, the detailed operational design and review.

This chapter sets out procedures for completion of the Needs Matrix forms (see copies, following pages). This is done in a series of steps: (1) rating composite threats; (2) noting the most appropriate generic types of aids to reduce these threats (navigational needs); (3) noting and assessing local means for reducing these threats; (4) noting specific aids provided against generic types; (5) assessing aids provided in relation to the threats and needs.

Note that the Needs Matrix forms are different for open water/outer approaches and confined water/inner approaches. This is because the mode of operation changes from navigation to pilotage. The threats may differ from open waters to confined waters. Where threats are common to both areas, their degree of significance may vary. The degree of appropriateness and effectiveness of any type of aid to navigation in addressing these threats often differs from open to confined waters, if only because of the different mode of operation.

4.2 Rating Composite Threats

In general, situations where there is a distinct danger of loss of life or an environmental disaster must be treated as ones where the threats to navigation are of Overriding Importance. The probabilities of such disasters occurring are, however, exceedingly difficult to calculate, although at some sites the dangers are self-evident (e.g. where ships carrying explosives or oil tankers operate in notoriously dangerous waters). Nonetheless, such clear situations are infrequent. Accordingly, threats are normally rated using the more measurable concept of impact on vessel operations and danger to the vessel, given the time and room needed to complete an evasive manoeuvre and/or to stop.

A five point scale is used here to rate composite threats: 1. Overriding Importance; 2. Highly Significant; 3. Significant; 4. Little Significance; and, 5. Not Applicable. While local knowledge and individual judgement should be used to ensure that ratings are appropriate, in general:

(1) A composite threat should be rated as of **Overriding Importance** if (a) as noted above, there is a clear danger to life or the environment; (b) there are several different types of "Highly

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MARINE AIDS
NEEDS MATRIX - OUTER APPROACHES/OPEN WATER

Date ....
District ....
Charts ....
Site ....

COMPOSITE THREATS	THREAT RATING (1 Overriding importance; 2 Highly significant; 3 Significant; 4 Little significance; 5 Not applicable) CAT I LR COMM	CAT II LOC COMM	CAT III PL CRAFT	NAVIGATIONAL NEEDS For generic aids system features to reduce threats (Check all most appropriate features to reduce significant threats)	✓	RATING OF GENERIC FEATURES (Ability to reduce threats) (A Greatly reduces; B Significantly reduces; C Somewhat reduces or reduces for some vessels only) CAT I LR COMM	CAT II LOC COMM	CAT III PL CRAFT	LOCAL MEANS/FEATURES FOR MEETING NEEDS (Specify and rate as 1 Fully adequate; 2 Partially adequate; 3 Marginally useful)	✓	AIDS PROVIDED List all established aids that contribute to reducing each threat by relevant generic aids system feature (note that any one aid may be listed several times)	COMMENTS (Apparent deficiencies and surplus aids)
1 SEA CONDITIONS	○	○	○	1 Visual markers on relevant hazards		A	A	A				
				21 Alternative route		C	A	A				
				3 Distinct visual markers for position		C	B	A				
				5 Visual markers for lateral motion		C	B	B				
				20 Anchorage		C	C	C				
2 PROXIMITY OF HAZARDS	○	○	○	1 Visual markers on relevant hazards		A	A	A				
				5 Visual markers for lateral motion		B	B	B				
				21 Alternative route		C	C	C				
3 COMPLEXITY OF TRACK	○	○	○	7 Visual boundary markers		A	A	A				
				11 Visual markers on turns		B	B	B				
				5 Visual markers for lateral motion		B	B	B				
				1 Visual markers on relevant hazards		B	B	B				
				3 Dist. visual markers for position		B	C	C				
4 DIMINISHED ROOM TO MANOEUVRE	○	○	○	7 Visual boundary markers		A	A	A				
				1 Visual markers on relevant hazards		A	A	A				
				5 Visual markers for relative motion		B	B	B				
				3 Distinct visual markers for position		C	C	C				
5 TRAFFIC DENSITY/MIX/CROSSING	○	○	○	23 Traffic separation		A	A	A				
				7 Visual boundary markers		B	C	C				
6 REDUCED VISIBILITY	○	○	○	2 Lighted visual markers on relevant hazards		A	A	A				
				16 Distinct radar signal on relevant hazards		A	C	N/A				
				15 Radar target on relevant hazards		A	C	N/A				
				17 Distinct radar signal for position		A	C	N/A				
				4 Distinct lighted visual markers for position		B	B	A				
				6 Lighted visual markers for lateral motion		B	B	B				
				18 Aural signal on relevant hazards		C	B	B				
				19 Distinct aural signal for direction		C	B	B				
				22 Port of refuge		C	C	B				
				20 Anchorage		C	C	B				
7 DARKNESS	○	○	○	A Lights on markers		A	A	A				
				4 Distinct lighted markers for position		A	A	A				
				17 Distinct radar signal for position		A	C	N/A				
				B Reflective material on markers		C	B	B				
				C Radar targets on markers		B	C	N/A				
8 ICE AND FREEZING SPRAY	○	○	○	5 Visual markers for lateral motion (land based)		A	B	N/A				
				17 Dist. radar signal for position (land-based)		A	C	N/A				
				3 Dist. visual markers for position (land based)		B	C	N/A				
9 CHANNEL SILTATION	○	○	○	8 Moveable visual markers		A	A	A				
				3 Distinct visual markers for position		C	C	C				
10 LACK OF DISTINCTIVE FEATURES FOR POSITIONING PILOT BOARDING STATION	○	○	○	3 Distinct visual markers for position		A	A	A				
				1 Visual markers relevant hazards		A	A	A				
				17 Distinct radar signal for position		B	C	N/A				
				21 Alternative route		B	C	C				
				20 Anchorage		B	C	C				

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MARINE AIDS
NEEDS MATRIX - INNER APPROACHES/CONFINED WATERS

Date ....

District ....

Charts ....

Site ....

COMPOSITE THREATS	THREAT RATING (1 Overriding importance; 2 Highly significant; 3 Significant; 4 Little significance; 5 Not applicable) CAT I LR-COMM	CAT II LOC COMM	CAT III PL-CRAFT	NAVIGATIONAL NEEDS For generic aids system features to reduce threats (Check all most appropriate features to reduce significant threats)		RATING OF GENERIC FEATURES (ability to reduce threats) A Greatly reduces; B Significantly reduces; C Somewhat reduces or reduces for some vessels only — CAT I LR COMM	CAT II LOC COMM	CAT III PL CRAFT	LOCAL MEANS/FEATURES FOR MEETING NEEDS Specify and rate as: 1 Fully adequate; 2 Partially adequate; 3 Marginally useful		AIDS PROVIDED List all established aids that contribute to reducing each threat by relevant generic aids system feature (note that any one aid may be listed several times)	COMMENTS (Apparent deficiencies and surplus aids)
1 SEA CONDITIONS				5 Visual markers for lateral motion		A	A	A				
				1 Visual markers on relevant hazards		A	A	A				
				3 Distinct visual markers for position		A	A	A				
				7 Visual boundary markers		B	A	A				
				13 Visual markers on off track hazards		C	B	B				
2 PROXIMITY OF HAZARDS				7 Visual boundary markers		A	A	A				
				1 Visual markers on relevant hazards		A	A	A				
				5 Visual markers for lateral motion		A	A	A				
				13 Visual markers on off track hazards		B	B	B				
				3 Distinct visual markers for position		B	C	C				
3 COMPLEXITY OF CHANNEL				7 Visual boundary markers		A	A	A				
				5 Visual markers for lateral motion		A	A	A				
				11 Visual markers on turns		A	A	B				
				1 Visual markers on relevant hazards		A	B	B				
				3 Distinct visual markers for position		B	C	C				
4 DIMINISHED ROOM TO MANOEUVRE				7 Visual boundary markers		A	A	A				
				1 Visual markers on hazards		A	A	A				
				5 Visual markers for lateral motion		A	B	B				
				3 Distinct visual markers for position		B	C	C				
5 TRAFFIC DENSITY/MIX/ CROSSING				23 Traffic separation		A	A	A				
				21 Alternative route		A	A	A				
				7 Visual boundary markers		A	B	B				
				20 Anchorage		C	C	C				
6 REDUCED VISIBILITY				8 Lighted visual boundary markers		A	A	A				
				7 Visual boundary markers		B	B	B				
				2 Lighted visual markers on relevant hazards		B	B	B				
				6 Lighted visual markers for lateral motion		B	B	B				
				4 Lighted distinct visual markers for position		B	B	B				
				19 Distinct aural signal for direction		B	B	B				
				1 Visual markers on relevant hazards		B	B	B				
				20 Anchorage		B	C	C				
				18 Aural signal on relevant hazards		C	B	B				
				14 Lighted visual markers on off-track hazards		C	B	B				
				16 Distinct radar signal on relevant hazards		B	C	NA				
				17 Distinct radar signal for position		B	C	NA				
				15 Radar targets on relevant hazards		B	C	NA				
7 DARKNESS				A Light on markers		A	A	A				
				B Reflective material on markers		C	B	B				
				C Radar reflectors on markers		B	C	NA				
8 ICE AND FREEZING SPRAY				5 Visual markers for lateral motion (land based)		A	A	NA				
				3 Distinct visual markers for position (land based)		B	C	NA				
				1 Visual markers on relevant hazards		C	C	NA				
9 CHANNEL SILTATION				9 Moveable visual markers		A	A	A				
				3 Distinct visual markers for position		C	C	C				
10 LACK OF DISTINCTIVE FEATURES FOR POSITIONING/ PILOT BOARDING STATION				3 Distinct visual markers for position		A	A	A				
				1 Visual markers on relevant hazards		A	A	A				
				17 Distinct radar signal for position		B	C					
				21 Alternative route		B	C	C				
				20 Anchorage		B	C	C				

Significant" individual threats underlying the composite threat and these tend to reinforce each other; (c) a few individual threats interact to produce exceedingly dangerous circumstances; or (d) one or more individual threats far exceed the point of being "Highly Significant";

(2) A composite threat should be rated **Highly Significant** if (a) one or more of the underlying individual threats is "Highly Significant"; or (b) there are several different types of "Significant" individual threats underlying the composite threat and these tend to reinforce each other;

(3) A composite threat should be rated **Significant** if (a) one or more of the underlying individual threats is "Significant" or (b) none of the underlying individual threats are "Significant" in themselves but combined effects nonetheless present a clear danger to vessels;

(4) A composite threat should be rated as of **Little Significance** if the general type of problem is relevant at the site but none of the above conditions apply; or,

(5) A composite threat should be classified as **Not Applicable** if the general type of problem is not relevant at the site (e.g., none of the vessels, or none of the vessels in a particular category, operate during the hours of darkness; there is no channel siltation or problem with ice or freezing spray).

Keeping these general definitions in mind, we can now consider specific threats. The composite ratings for each type of threat and category of vessel should be entered in the circles provided on the Needs Matrix form under Threat Rating.

4.2.1 Sea Conditions

This composite threat includes all factors of sea conditions which can threaten the safety of navigation, including four individual factors already given preliminary ratings on the Preliminary Threat Rating Form: Wind Speed, Wave Height, Along Track Current Speed and Across Track Current Speed. Fluctuating Water Depth (see Site Data Sheet) should also be taken into account here. To arrive at a composite rating, the ratings and the combined effects of all these elements of sea conditions should be considered in relation to distance from hazards and from other vessels when passing. In addition whether there is good weather broadcasting in the area and whether users have radios must be given some consideration in rating this threat .

4.2.2 Proximity of Hazards

This threat has been given preliminary ratings as "Distance From Hazard" on the Preliminary Threat Rating Form. It should now be considered in conjunction with sea conditions, the incidence of reduced visibility, and volume of traffic (see Site Data Sheet).

4.2.3 Complexity of Track/Channel

One element of this threat, "Angle of Turn in Channel", has been given ratings on the Preliminary Threat Rating Form. However, the number of turns (to avoid hazards) and the number of hazards must also be taken into account in rating this threat, as must sea conditions, the incidence of reduced visibility, and volume of traffic.

4.2.4 Diminished Room to Manoeuvre

The primary element of this composite threat, "Minimum Channel Width", has been rated on the Preliminary Threat Rating Form. However, to rate the composite threat, the extent (length) of the restricted channel must be taken into account together with factors that necessitate manoeuvring (turns in the channel, volume of traffic, wind, current and wave height) and factors that adversely affect manoeuvring (distance from hazards and other vessels, reduced visibility, wind, current and wave height).

4.2.5 Traffic Density/Mix/Crossing

One aspect of this threat has been rated as "Distance from other vessel when passing", but other considerations are more important. This threat is to be considered significant whenever the traffic density, the mix of various types of vessels, and vessels crossing and meeting create a threatening situation. Local knowledge is required to rate this threat, but the judgement must be supported by the traffic data entered on the Site Data Sheet. The rating of this threat must be considered in conjunction with other factors which might exacerbate it: diminished room to manoeuvre, proximity of hazards, channel complexity and the incidence of reduced visibility.

4.2.6 Reduced Visibility

This threat has been given preliminary ratings. The total incidence of reduced visibility (for the full navigational season not just the worst month), together with the extent that the rating points are exceeded, should be taken into account in the final ratings.

4.2.7 Darkness

This threat is applicable only where there is night-time traffic (see Site Data Sheet, item (4)). For typical situations where the site is being used during the hours of darkness, this threat should be rated:

Category I	-	Long-Range Commercial	: 2 - Highly Significant
Category II	-	Local Commercial	: 3 - Significant
Category III	-	Pleasure Craft	: 4 - Of Little Significance

The lower ratings for Category II and Category III are in part a result of the standard practice of putting reflective material on aids. Provided they carry and use a searchlight, vessels in these two categories can utilize this feature. Moreover, pleasure craft seldom need to be out after dark. Higher ratings should be given than these standard ones where there is a high volume of traffic during the hours of darkness and one or more of the previously noted threats (sea conditions, proximity of hazards, complexity of track/channel, diminished room to manoeuvre, reduced visibility) reinforce the problems and dangers of night-time vessel movement.

4.2.8 Ice and Freezing Spray

Note that this threat is only considered relevant for commercial vessels (Categories I and II). The prudent pleasure craft operator will not attempt to navigate when ice and/or freezing conditions prevail.

Freezing spray obscures landmarks and aid marks, and affects visibility and other aspects of navigation. Ice is a major hazard for vessels. It is also a major threat to the integrity of standard buoys and thus these normally have to be removed for the ice season. They may be replaced by ice spars or it may be necessary to provide land-based aids to meet the needs of mariners.

If vessels normally operate at the site when there is ice (consult local knowledge) or when there is a significant probability of freezing spray (i.e., greater than 20% moderate, 10% heavy or 5% severe during the worst month of the navigation season, see Site Data Sheet) this threat is to be considered "Significant". Consider this threat in conjunction with the foregoing threats to determine whether it should be rated "Significant", "Highly Significant" or of "Overriding Importance".

4.2.9 Channel Siltation

The Site Data Sheet shows whether or not there is noticeable siltation. Where there is a noticeable degree of siltation, local knowledge of the severity and impacts of this siltation is needed to rate this threat. This threat is to be considered "Significant" whenever the siltation is such that it interferes with the safety of navigation. It must be considered in conjunction with the capacity of the users (their local knowledge and the design of their vessels), threats from sea conditions, and reduced visibility.

4.2.10 Lack of Distinctive Features for Positioning/Pilot Boarding Station

This threat is to be considered "Significant" when the shoreline is either featureless or when there are so many similar features that users cannot make a positive visual or radar observation that will assist the determination of position during coastal navigation or for entering the pilot boarding area or the approaches to a harbour. As a guideline, to be used as a landfall marker, any such features should, ideally, have four distinctive, describable aspects.

This threat is basically one of making landfall and is to be considered in conjunction with other threats, particularly: proximity of hazards, reduced visibility, diminished room to manoeuvre (narrow opening), and sea conditions.

4.3 Identifying Generic Navigational Needs

The Needs Matrix Forms identify needs of mariners in terms of generic types of markers and signals that can reduce each category of composite threat. These have been rated in consultation with users for their effectiveness in reducing each type of threat for each category of user. These ratings are:

A. Greatly reduces the threat

B. Significantly reduces the threat

C. Somewhat reduces the threat or reduces the threat for some vessels in the category (e.g., radar targets will assist those fishing vessels in Category II who are equipped with radar but do not qualify as Category I because of lack of other electronic equipment, because installations have not been inspected to ensure they are within regulations or because the operator has not been fully trained and certified).

Note that these ratings measure only the relative effectiveness for reducing threats, not the relative economy or cost-effectiveness. This latter aspect is often site specific (e.g., providing an alternative route for local commercial vessels and pleasure craft to use when sea conditions are dangerous might be very expensive at one site, because a large number of markers would be required, and very easy and relatively inexpensive at another).

Also note that the actual ratings vary by the category of user, by the type of threat that is being addressed, and between open and confined waters.

The types of navigational needs for markers and signals have been specified as follows:

1. Visual marker on relevant hazard
2. Lighted visual marker on relevant hazard
3. Distinctive visual marker for position
4. Lighted distinctive visual marker for position
5. Visual marker for lateral motion
6. Lighted visual marker for lateral motion
7. Visual boundary marker
8. Lighted visual boundary marker
9. Moveable visual marker
10. Lighted moveable visual marker
11. Visual marker on turn
12. Lighted visual marker on turn
13. Visual marker on off-track hazard
14. Lighted visual marker on off-track hazard
15. Radar target on relevant hazard
16. Distinctive radar signal on relevant hazard
17. Distinctive radar signal for position
18. Aural signal on relevant hazard
19. Distinctive aural signal for direction
20. Marker for anchorage
21. Marker for alternative route
22. Marker for port of refuge
23. Marker for traffic separation

These navigational needs are defined and linked to specific types of aids in the table "Definitions of Navigational Needs/System Features and Short-Range Aids Selection Matrix", which follows (p. 4-9 to 4-13).

Note that for threat number 7 "Darkness" on the "Needs Matrix", three very general features have been used:

A. Lights on markers

B. Reflective material on markers

C. Radar reflective targets.

These refer to the need for adding features to aids to make them usable in darkness or selecting aids which are better radar targets.

At this step in the completion of the form, the apparent needs of mariners for system features to reduce "Significant" or greater threats can be identified. To do this the following principles must be kept in mind:

DEFINITIONS OF NAVIGATIONAL NEEDS AND SHORT-RANGE AIDS SELECTION MATRIX

A. DEFINITION OF NAVIGATIONAL NEED/SYSTEM FEATURES	NOTES TO COLUMNS A & B	B. SUITABLE SHORT- RANGE AIDS (to suit user, cost/benefit, ops.& L.O.S. standards)
1. <u>VISUAL MARKER ON RELEVANT HAZARD</u> An object marking the location[1] of a shoal, ledge, wreck or any other fixed obstruction over which a vessel cannot safety pass. A relevant hazard is one which presents a danger to the mariner because of its proximity[2] to the boundaries of an established route (track) to the extent that fixing methods do not allow adequate tolerance to keep clear of the hazard with certainty under the various conditions that generate threats to safety (navigational factors). The marker must be identifiable[3] (under prescribed conditions) as to its function or type aid (i.e., port hand, starboard hand, north cardinal, etc.) at a distance that will give the intended user sufficient warning to aid his safe voyage past the hazard.	Normally identifable as to type and function by: shape, colour, number 1. See Directive 2-2400 (old A-1)Aids and Waterways Operations Manual TP1526. Guidelines for location of markers on rel. hazards (buoys). 2. See policy element A24 Operations Manual, TP1526 3. See Technical Analysis, Buoy Standardization, Summary Report, Sect. 5.2 pg. 82, policy element A3, Ops. Manual TP1526, and Appendix A, Table A.7 and Figures A.4 and A.5.	Buoy, dolphin, pier, daybeacon, stake, daymark
2. <u>LIGHTED VISUAL MARKER ON RELEVANT HAZARD</u> A light marking the location of a shoal, ledge, or any other fixed obstruction over which a vessel cannot safely pass. A relevant hazard is one which presents a danger to the mariner because of its proximity to the boundaries of an established route/track to the extent that fixing methods do not allow adequate tolerance to keep clear of the hazard with certainty under the various conditions that generate threats to safety (navigational factors). The light must be identifiable[1] (under prescribed conditions) as to its function or type of aid (e.g., port hand, starboard hand, north cardinal, etc.) at a distance[2] that will give intended users sufficient warning to aid their safe voyage past the hazard.	Normally identifiable as to type and function by: colour of light, periodic rhythm of light 1. See Appendix A, Table A.6, "Buoy Light Flash Characteristics". 2. Guideline required.	Light/lantern Under certain conditions reflective material may be suitable.
3. <u>DISTINCTIVE VISUAL MARKER FOR POSITIONING</u> An object that is established to assist mariners to determine vessel position. This marker must be identifiable (under prescribed conditions) as to its exact location at a distance[1] that will be sufficient to aid the safe voyage of the intended user.	Normally identifiable as to exact location by a combination of shape and colour. May also be identifiable by numbers, names etc. 1. See policy element A3, Ops. Manual TP1526, and Appendix A, Tables A.7 and Figures A.4 and A.5.	Where position fixing is required by such users as foreign vessels making landfall, the suitable aid may be a major lightstation. Where users have local knowledge or in confined waters the suitable aids may be minor daymarks (lightstations) or daybeacons. In some instances a fairway buoy identifiable by name or letter(s) may be suitable.

DEFINITIONS OF NAVIGATIONAL NEEDS AND SHORT-RANGE AIDS SELECTION MATRIX

A. DEFINITION OF NAVIGATIONAL NEED/SYSTEM FEATURES	NOTES TO COLUMNS A & B	B. SUITABLE SHORT- RANGE AIDS
4. DISTINCTIVE LIGHTED VISUAL MARKER FOR POSITIONING A light that is established to assist mariners to determine vessel position. This light must be identifiable[1] (under prescribed conditions) as to its exact location at a distance[2] that will be sufficient to aid the safe voyage of the intended user.	Normally identifiable as to exact location by a combination of colour of light and periodic rhythm of light. 1. Guidelines required. 2. See Lists of Lights - Nomogram - (Height of light - Height of observer - Geographical Range). 3. See Appendix A, Table A.6 "Buoy Light Flash Characteristics".	Light on major coastal station. Where users have local knowledge, or in confined waters, the suitable aid may be provided with less distinctive flash characters.[3] In some instances, the light on a fairway buoy may be suitable.
5. VISUAL MARKER FOR LATERAL MOTION An object or objects established to assist mariners to detect lateral motion of the vessel. The object(s) must be visible (under prescribed conditions) at sufficient distance to be identiable[1] as to type (e.g., single or dual station range). The object(s) must also allow mariners to detect lateral motion[2] with sufficient warning to take the necessary action to maintain the vessel within the safe limits of the prescribed channel.	Normally identifiable by shape and colour. Lateral motion detected by changing visual means such as the "opening" and closing of visual markers. 1. See policy element A3, Ops. Manual TP1526, and Appendix A, Table A.7 and Figures A.4 and A.5. 2. Standard design formula required.	Single or dual station range. In some instances, a single daymark may be used in conjunction with a natural object.
6. LIGHTED VISUAL MARKER FOR LATERAL MOTION A light(s) established to assist the mariners to detect lateral motion of the vessel. The light(s) must be visible (under prescribed conditions) at sufficient distance1 to be identifiable as to type (e.g., single or dual station range). The light(s) must also allow mariners to detect lateral motion[3] with sufficient warning to take the necessary action to maintain the vessel within the safe limits of the prescribed channel.	Normally identifiable as a range by a combination of colour of light and periodic rhythm of light[1]. 1. Guidelines required. 2. Guidelines required. 3. Guidelines required.	Single or dual station range. Sector light.
7. VISUAL BOUNDARY MARKER An object established to assist mariners in maintaining vessel direction between visual or lighted visual markers on relevant hazards or to mark the outer boundaries of traffic separation lanes. The object must be visible (under prescribed conditions) at sufficient distance[1] to allow mariners to maintain the vessel within the safe limits of the prescribed channel.	Normally identifiable by shape and/or colour[2]. Not to be confused with buoys marking the edge of a dredged cut. The dredged cut is a relevant hazard. 1. Guidelines required. 2. See Policy Element A24, Ops. Manual TP1526	Buoy, dolphin.

DEFINITIONS OF NAVIGATIONAL NEEDS AND SHORT-RANGE AIDS SELECTION MATRIX

A. DEFINITION OF NAVIGATIONAL NEED/SYSTEM FEATURES	NOTES TO COLUMNS A & B	B. SUITABLE SHORT- RANGE AIDS
8. <u>LIGHTED VISUAL BOUNDARY MARKER</u> A light established to assist mariners in maintaining vessel direction between lighted visual markers on relevant hazards or to mark the boundaries of traffic separation lanes. The light must be visible (under prescribed conditions) at sufficient distance[1] to allow mariners to maintain the vessel within the safe limits of the prescribed channel.	Normally identifiable by colour of light and periodic rhythm of light[2] 1. Guidelines req'd. 2. See Appendix A, Table A.6, "Buoy Light Flash Characteristics".	Lighted buoys.
9. <u>MOVEABLE VISUAL MARKER</u> A moveable object used to mark the present location of a relevant hazard (see def. 1) or to assist mariners detect lateral motion of the vessel. (see def. 5).	These markers are normally required wherever the location of hazards is subject to change. Normally, this is caused by siltation or extreme variations in water depths.	Buoys, ranges on skids.
10. <u>LIGHTED MOVEABLE VISUAL MARKER</u> A moveable lighted object used to mark the present location of a relevant hazard (see def. 1) or to assist mariners to detect lateral motion of the vessel. (see def. 5).	These markers are normally required wherever the location of hazards is subject to change. Normally, this is caused by siltation or extreme variations in water depths.	Lights on buoys, lighted ranges on skids, adjustable sector lights.
11. <u>VISUAL MARKER ON TURN</u> An object marking the location of a turn (it may also mark a relevant hazard as in def. 1) in the established route. The marker must be identifiable[1] as to its function or type of aid at a distance that will give the intended users sufficient warning to aid their safe voyage through the turn.	Normally identifiable as to type or function by: shape, colour, number. 1. See policy element A-24 Ops. Manual, TP1526.	Buoy, dolphin, pier, daybeacon, stake, daymark.
12. <u>LIGHTED VISUAL MARKER ON TURN</u> A light marking the location of a turn (it may also mark a relevant hazard as in def. 2) in the established route. The light must be identifiable[1] as to its function or type of aid at a distance that will give intended users sufficient warning to aid their safe voyage through the turn.	Normally identifiable as to type and function by colour and periodic rhythm of light. 1. See Appendix A, Table A.6, "Buoy Light Flash Characteristics".	Light/lantern. Under certain conditions reflective material may be suitable.

DEFINITIONS OF NAVIGATIONAL NEEDS AND SHORT-RANGE AIDS SELECTION MATRIX

A. DEFINITION OF NAVIGATIONAL NEED/SYSTEM FEATURES	NOTES TO COLUMNS A & B	B. SUITABLE SHORT- RANGE AIDS
13. <u>VISUAL MARKER ON OFF-TRACK HAZARD</u> An object marking the location of a shoal, ledge, wreck or any other fixed obstruction over which a vessel cannot safely pass. An off-track hazard is one which does not normally present a danger to the mariner because of its proximity to the boundaries of an established route. (See relevant def. 1). The marker must be identifable as in def. 1.	Normally only required when users are faced with a combination of highly significant threats in confined waters, such as extreme sea conditions and ships/size/manoeuvrability.	Buoy, dolphin, pier, daybeacon, stake, daymark.
14. <u>LIGHTED VISUAL MARKER ON OFF-TRACK HAZARD</u> A light marking the location of a shoal, ledge, wreck or any other fixed obstruction over which a vessel cannot safely pass. An off-track hazard is one which does not normally present a danger to the mariner because of its proximity to the boundaries of an established route. (See relevant def. 1). The marker must be identifiable as in def. 2.	(As in def. 13).	Light/lantern. Under certain conditions reflective material may be suitable.
15. <u>RADAR TARGET ON RELEVANT HAZARD</u> An object marking the location of a relevant hazard (see def. 1 Visual Marker on relevant hazard) that has the ability to effectively reflect radar signals at sufficient distance that will give the intended users sufficient warning to aid their safe voyage past the hazard[1].	Normally provided by a tetrahedron shaped radar reflector although many structures and buoys present a sufficient target. See Appendix A, Table A.1, "Visual and Radar Range of Buoys."	Radar reflector on a buoy, dolphin, or tower.
16. <u>DISTINCTIVE RADAR SIGNAL ON RELEVANT HAZARD</u> An electronic device marking the location of a relevant hazard (see def. 1) by transmitting a coded radar signal that can be identified at a sufficient distance to give the intended usesr sufficient warning to aid their safe voyage past the hazard[1].	Normally provided by a Racon triggered by shipboad radar. Signal is usually a coded pulse (Morse Code). 1. See Canadian Aids to Navigation System booklet, Radar Beacons (Racons).	Racon transceiver on a buoy, dolphin, or tower; under some conditions a radar reflector or the structure itself may provide a sufficiently distinctive signal for positive identification of position.
17. <u>DISTINCTIVE RADAR SIGNAL FOR POSITION</u> An electronic device established to assist mariners to determine vessel position by transmitting a coded radar signal that can be identified as to its exact location at a distance that will be sufficient to aid the safe voyage of the intended user.	Normally provided by a Racon triggered by shipboad radar. Signal is usually a coded pulse (Morse Code). 1. See Canadian Aids to Navigation System booklet, Radar Beacons (Racons).	Racon; as noted above, under rare conditions a radar reflector may be distinctive enough for positive identification of position.

DEFINITIONS OF NAVIGATIONAL NEEDS AND SHORT-RANGE AIDS SELECTION MATRIX

A. DEFINITION OF NAVIGATIONAL NEED/SYSTEM FEATURES	NOTES TO COLUMNS A & B	B. SUITABLE SHORT- RANGE AIDS
18. AURAL SIGNAL ON RELEVANT HAZARD A sound producing device marking the location of a relevant hazard (see def. 1).	Normally a sound buoy or a fog signal which may also be a distinctive aural signal for direction. 1. See policy element A5, Operations Manual, TP1526.	Bell or whistle buoy or fog signal.
19. DISTINCTIVE AURAL SIGNAL FOR DIRECTION A sound producing device that provides the mariner with an indication of direction. The sound produced must be identifiable[1] (under prescribed conditions) as to its location at a distance that will be sufficient to aid the safe voyage of the intended user.	Normally provided by a coded fog signal which may also provide an aural signal on a relevant hazard. 1. See policy element A5, Operations Manual, TP1526.	Fog signal; under certain conditions the bell or whistle on a fairway buoy may be distinctive enough to assist mariners to determine vessel direction.
20. ANCHORAGE MARKER An object which marks an anchorage area or defines its limits. The marker must be identiable[1] (under prescribed conditions) as to its function at a distance[2] that will give intended users sufficient notice to aid their safe voyage to anchorage.	1. See Anchorage buoy, policy element A24, Ops. Manual, TP1526. 2. See "No Anchorage" sign policy element A3, Ops. Manual, TP1526.	Buoys, dolphins, daybeacon, daymark.
21. ALTERNATIVE ROUTE MARKER An object marking a route which is an alternative to the primary established route.	Normally alternative routes are marked as a result of threats from sea conditions and ships size/manoeuvrability, traffic density, or a mix of traffic such as large commercial vessels and pleasure craft.	This alternative route marker may be any type of aid as long as it clearly directs the mariner in the alternate track.
22. PORT OF REFUGE MARKER An object marking the entrance to a temporary safe-harbour or port of refuge.	This is a marker in addition to those provided for the primary established route.	Buoys, dolphin, daybeacon, daymark.
23. TRAFFIC SEPARATION MARKER An object marking the separation line or zone between vessels that are travelling in opposite directions.	May be located on the centreline of a channel or may also be boundary markers (see def. 7) when upstream and downstream traffic is separated with a row of buoys on both channels.	Buoys.

(a) The more severe the threat rating the more effective the selected markers and signals must be. Where a threat is of "Overriding Significance", several types might be required to sufficiently reduce the threat.

(b) Where there is a mix of vessel categories, different markers and signals may be required because of differences in their modes of operation/navigation.

(c) Ratings take into account only relative effectiveness. Economy and cost-effectiveness must also be considered, so that the cost of the system features selected as most appropriate should also be relative to the significance of the threat as well as the local economic impacts of marine activities. In general, expensive options would only be considered appropriate where the threat is of "Overriding Significance" and/or where economically justified.

(d) In considering what might be appropriate to reduce one threat, take into account the fact that certain markers and signals are necessary to reduce another (e.g., where an alternate route is necessary because of severe sea condition, this might be sufficient to meet the needs arising out of a "Significant" threat of proximity of hazards).

With these principles in mind and with specific knowledge of the site gained thus far in the analysis, for each threat that has been rated "Significant" or higher, check off the most appropriate types of markers and signals in the boxes provided on the Needs Matrix form.

4.4 Local Means/Features for Meeting Needs

When local means (other than short-range aids) can be used to meet or lessen the needs, or reduce the threats to the mariner, these shall be listed in the Local Means column of the Needs Matrix.

Some examples of local means and the needs they may meet or reduce are:

Local Means	Needs
prominent (charted) landmarks	- visual marker on relevant hazard - distinctive visual marker(s) for position
natural or man made transits	- visual marker for lateral motion

tug assistance	- marker(s) on turns
V.T.S.	- marker(s) for traffic separation - boundary markers, etc.
local knowledge	- distinctive visual marker(s) for position
local knowledge & searchlight	- lights on markers
local regulations	- marker(s) for traffic separation

In the boxes provided, rate the adequacy of these means to meet the identified needs and reduce threats to an acceptable level as:

F : Fully adequate

P : Partially adequate

M : Marginally useful

(Local means that are not at least marginally useful should not be listed.)

4.5 Aids Provided

All short-range aids that have been established at the site (see Site Inventory) are to be listed on the Needs Matrix Forms under the "Aids Provided" column against (i.e., in line with) their related types of navigational needs for all relevant threats (i.e., all threats rated "Significant" or higher where the generic feature appears). However, it is possible that an established aid may not relate to any threat rated as "Significant" or higher. Where this occurs, a notation should be made in the Comments column (see below, Section 5.6).

Each aid is to be listed as often as it meets any of the needs for each of the threats rated significant or greater. Where there are large numbers of one type of aid they do not all have to be described individually. They may be grouped as shown in the following examples:

- 12 spar buoys on dredged cut (Nos. _______________)
- 4 sets of ranges on inner approaches (Nos. ___________)
- 6 lighted sound buoys on hazards (Nos. _____________)

4.6 Comments

As a final step in completing the Needs Matrix Forms, the aids provided should be compared with the identified needs and the available local means for meeting these needs. Appropriate notation should be made in the "Comments" column where it appears that the aids provided, together with local means, go much further in reducing the threat than seems to be warranted or where it appears that the aids and means are insufficient (including where aids are needed but not provided). While actual deficiencies or surpluses to requirements can only be determined after operational analysis and user consultations, these notations will assist and guide these processes.

Also, at this stage notation should be made of any established aids at the site which do not address at least one threat that has been rated "Significant" or higher. The established aids should be listed against a threat they might be intended to address, even though this threat has not been rated as significant, and the comments should be noted on these lines in the final column.

4.7 Needs Analysis Example

These procedures can now be applied to our example site, Burnt Island in Newfoundland. However, as previously noted, the scale of the CHS chart is too small to permit an analysis of the inner approaches. Thus, our example must be confined to the outer approaches.

To conduct the analysis, it is necessary to have:

(a) the site chart;

(b) the completed Preliminary Threat Rating Form;

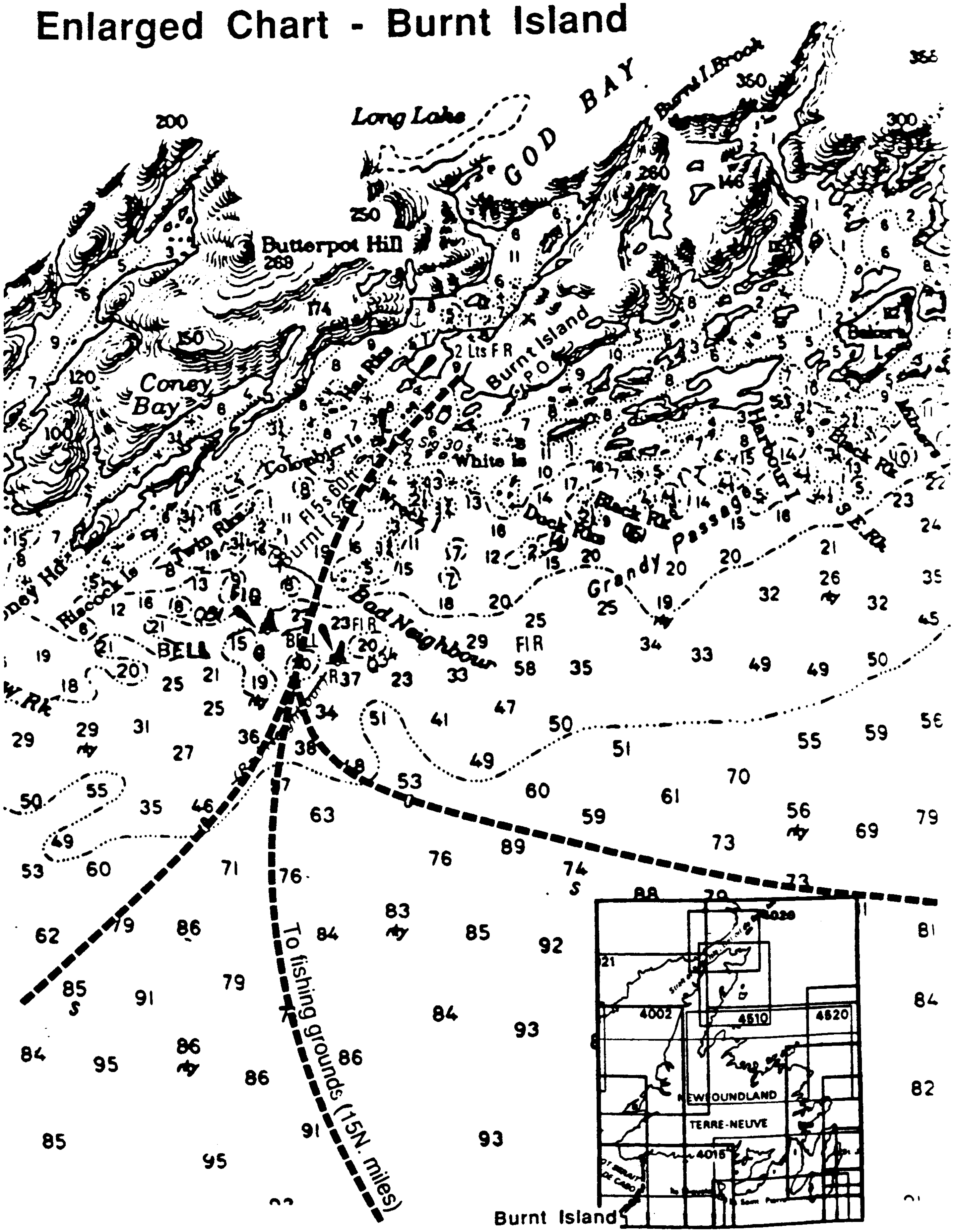
(c) the completed Site Data Sheet, plus the AES tables specified in Chapter 2 which give the necessary weather details for this site;

(d) local knowledge including information from experienced CCG officers and user interviews/questionnaires; and

(e) relevant files, including previous correspondence.

Using these information sources, the Needs Analysis for the outer approaches at Burnt Island can be completed step by step. This form can be completed column by column (i.e., first rating the threats, then identifying the generic needs, then noting local means, etc.) or threat by threat (i.e., first rating "Sea Conditions" as a composite threat, its related needs, relevant local features, aids provided which reduce the threat, comments in deficiencies, etc., then doing the same for "Proximity of Hazards", etc.). The latter procedure has been followed here. An enlarged site chart and a completed Needs Analysis form are shown on the following pages.

Enlarged Chart - Burnt Island



Canadian Coast Guard / Garde côtière canadienne

MARINE AIDS
NEEDS MATRIX - OUTER APPROACHES/OPEN WATER

Date: Dec '88
District: St John's NFLD
Charts: 4655
Site: Burnt Island

COMPOSITE THREATS	THREAT RATING (1. Overriding importance 2. Highly significant 3. Significant 4. Little significance 5. Not applicable) CAT-I LR-COMM	CAT-II LOC-COMM	CAT-III PL CRAFT	NAVIGATIONAL NEEDS For generic aids system features to reduce threats (Check all most appropriate features to reduce significant threats)	✓	RATING OF GENERIC FEATURES (Ability to reduce threats) A. Greatly reduces B. Significantly reduces C. Somewhat reduces or reduces for some vessels only — CAT I LR COMM	CAT II LOC COMM	CAT III PL CRAFT	LOCAL MEANS/FEATURES FOR MEETING NEEDS (Specify and rate as: 1 Fully adequate 2 Partially adequate 3 Marginally useful)	Rate	AIDS PROVIDED (List all established aids that contribute to reducing each threat by relevant generic aids system feature; note that any one aid may be listed several times)	COMMENTS (Apparent deficiencies and surplus aids)
1 SEA CONDITIONS	5	1	1	1 Visual markers on relevant hazards	✓	A	A	A			Buoys QB, Q34	*Charted markers seem
				21. Alternative route		C	A	A				inadequate, a marker needed for
				3. Distinct visual markers for position	✓	C	B	A			Colombier Island light station LL156	Western Island; Q34 may be
				5. Visual markers for lateral motion		C	B	B				too far off, Red Neighbour
				20. Anchorage		C	C	C				for inbound traffic
2 PROXIMITY OF HAZARDS	5	1	1	1 Visual markers on relevant hazards	✓	A	A	A	Most users have local knowledge	2	QB, Q34	* as above
				5. Visual markers for lateral motion		B	B	B	but this is necessary			
				21. Alternative route		C	C	C	because of poor chart			
3 COMPLEXITY OF TRACK	5	4	4	7 Visual boundary markers		A	A	A				
				11 Visual markers on turns		B	B	B				
				5. Visual markers for lateral motion		B	B	B				
				1 Visual markers on relevant hazards		B	B	B				
				3. Dist. visual markers for position		B	C	C				
4 DIMINISHED ROOM TO MANOEUVRE	5	3	3	7. Visual boundary markers		A	A	A				
				1 Visual markers on relevant hazards	✓	A	A	A			QB, Q34	* as above
				6. Visual markers for relative motion		B	B	B				
				3. Distinct visual markers for position		C	C	C				
5 TRAFFIC DENSITY/MIX/CROSSING	5	4	4	23 Traffic separation		A	A	A				
				7 Visual boundary markers		B	C	C				
6 REDUCED VISIBILITY	5	1	1	2 Lighted visual markers on relevant hazards	✓	A	A	A	as above	2	QB, Q34	* can't see but lights may be
				10 Distinct radar signal on relevant hazards		A	C	N/A				needed on any added markers
				15 Radar target on relevant hazards	✓	A	C	N/A			on Buoys QB, Q34	any added markers should be
				17. Distinct radar signal for position		A	C	N/A				good radar targets
				4 Distinct lighted visual markers for position	✓	B	B	A			LL156	
				6 Lighted visual markers for lateral motion		B	B	B				
				18. Aural signal on relevant hazards	✓	C	B	B			Bells on QB, Q34,	[illegible] added markers [illegible] and
				19. Distinct aural signal for direction		C	B	B			foghorn at Colombier Island light station	[illegible] foghorn at Colombier is
				22 Port of refuge		C	C	B				may be redundant.
				20 Anchorage		C	C	B				
7 DARKNESS	5	1	5	A Lights on markers	✓	A	A	A			on Buoys QB, Q34	* as above but lights may be
				4. Distinct lighted markers for position	✓	A	A	A			LL156	needed on any added [illegible]
				17 Distinct radar signal for position		A	C	N/A			—	
				B Reflective material on markers	✓	C	B	B			on QB, Q34	* added markers should have reflective
				C. Radar targets on markers	✓	B	C	N/A			on QB, Q34	material and be good radar targets
8 ICE AND FREEZING SPRAY	5	2	5	5 Visual markers for lateral motion (land-based)		A	B	N/A				
				17 Dist. radar signal for position (land-based)		A	C	N/A				
				3 Dist. visual markers for position (land based)	✓	B	C	N/A			Colombier Island light station LL156	
9 CHANNEL SILTATION	5	5	5	9 Moveable visual markers		A	A	A				
				3 Distinct visual markers for position		C	C	C				
10 LACK OF DISTINCTIVE FEATURES FOR POSITIONING/PILOT BOARDING STATION	5	3	3	3 Distinct visual markers for position	✓	A	A	A	* as above	2	LL156	* as above
				1 Visual markers relevant hazards	✓	A	A	A			QB, Q34	
				17 Distinct radar signal for position		B	C	N/A				
				21 Alternative route		B	C	C				
				20 Anchorage		B	C	C				

4.7.1 Sea Conditions

On the Preliminary Threat Rating Form two of the underlying individual factors for Sea Conditions -- "Wind Speed" and "Wave Height" -- are rated "Highly Significant" for both categories of traffic, while one of the factors -- "Across Track Current Speed" -- rates as "Significant" for commercial traffic (Category II). Two related factors are also rated "Highly Significant" -- "Distance from Hazard" and "Visibility". The Site Data Sheet shows that both "Wind Speed" and "Wave Height" distinctly exceed the requirements for a "Highly Significant" rating: Wind Speed exceeds 30 knots 17% of the year versus a rating point of 10%, and exceeds 35 knots 8% of the time; Wave Height exceeds 2 meters 31% of the time versus a rating point of 10%, and exceeds 3 meters 14% of the time. There is also a six foot tidal variation which will affect what is and is not a submerged hazard. Finally, the chart shows that the site is littered with hazards, some of which are very close to the traffic paths. Considering all these factors, it is clear that Sea Conditions pose an extremely serious threat at the site and must be given the highest rating, "1. Overriding Importance" for both categories of traffic.

With this high a rating the best means possible should be used to reduce the threat. Thus all relevant hazards should be marked, as this is the most effective means to reduce this threat for all traffic. In other areas with such severe sea conditions, an alternate route (for different wind and wave directions, etc.) might also be provided but this is not feasible here (see chart). Next in order of strength of effect is the provision of markers for position, which is essential here, given the severity of sea conditions and winter ice conditions (which necessitate the lifting of the two buoys marking hazards and only allow the replacement of the inner most one with an unlit spar buoy). The next possibility is markers for lateral motion (ranges), which might be provided rather than marking every hazard. Given the situation, this less effective option does not seem appropriate, nor does the final choice "Anchorage". Thus "Visual markers on relevant hazards" and "District visual markers for position" have been ticked as relevant needs.

No specific local means were identified against these needs.

Existing Buoys QB1 and Q34 mark hazards. QB1 is a port-hand buoy to keep traffic away from Twin Rocks. Q34 is a starboard-hand buoy serving several functions. It is primarily a coasting buoy to help passing traffic to avoid Bad Neighbour. It also serves as a landfall marker to denote the entrance to the outer approaches to Burnt Island. As a starboard-hand buoy it does serve those entering the harbour as a warning of the hazard of Bad Neighbour but it is a bit far away from this hazard to provide adequate warning, given wave and wind conditions that could take a vessel off track. As the track gets closer to shore, it passes very close to Wreck Island, but this is not marked. While an experienced mariner might readily avoid danger by staying closer to the port-hand side and by using Colombier Island Lightstation to fix position, the lack of a starboard hand marker at Wreck Island could be a serious deficiency. The comments on the form note these deficiencies for reference during the operational analysis.

4.7.2 Proximity of Hazards

On the Preliminary Threat Rating Form, "Distance from Hazard" is rated as a "Highly Significant Threat" for both classes of vessels; that is, of necessity they pass extremely close to some hazards (within 100') which is problematic given the ability of the vessels to manoeuvre. Considering this in conjunction with sea conditions (severe), visibility problems ("Highly Significant") and volume of traffic (heavy fishing traffic, Category II), the proximity of the hazards is a very serious problem. Thus, this threat also merits a rating of "1. Overriding Importance".

Fortunately, most users of this harbour are local residents or regular visitors. While, as shown on the form, this partially offsets the threat, nevertheless the poor charting (too small scale) both makes this local knowledge essential and is a problem in itself. Visitors have had serious problems at this site and, therefore, the marking of hazards must be thorough. This is noted as a need. Buoys QB1 and Q34 partially meet this need but, as noted for sea conditions, Q34 appears to be poorly placed (i.e. too far away) to serve as a fully adequate marker for Bad Neighbour and there appears to be a need for a starboard-hand marker on Wreck Island.

4.7.3 Complexity of Track

While the outer approaches are littered with hazards, the track through this part of the site is fairly straight with a gentle turn required in one direction only (inbound to starboard). Thus, this is not a significant threat here.

4.7.4 Diminished Room to Manoeuvre

The primary element of this composite threat is "Minimum Channel Width" which is not problematic for any of the users. However, because of the number and proximity of hazards and the severe sea conditions, local judgement assessed this threat as "Significant" for all vessels.

While a range (marker for lateral motion) would be sufficiently effective to meet the degree of threat, since the more effective alternative of markers on relevant hazards is required for the level of other threats, these hazard markers are sufficient to address this threat.

The previous remarks concerning the hazard marking also apply here.

4.7.5 Traffic Density/Mix/Crossing

"Distance from other vessel when passing", which is one aspect of this composite threat, is not a significant threat for any of the types of vessels operating at this site. While there is a large volume of fishing traffic (Category II) at the site, these would tend to be going in the same direction at the same time. Other vessel traffic is minimal. Thus, this composite threat is of little significance at this site.

4.7.6 Reduced Visibility

As noted on the Preliminary Threat Rating Form, "Visibility" is a "Highly Significant" threat to all classes of vessels at this site. In fact, as previously noted, the incidence of reduced visibility distinctly exceeds the level for this rating. Moreover, the AES data table "Percentage and Frequency of Visibility and Good Shipping Weather" shows that visibility is less than 1.1 nautical miles more than 10% of the time for four months of the year and less than 2.2 nautical miles more than 10% of the time every month of the year. Considering the incidence of reduced visibility during the worst month and during the whole year, together with the number and proximity of the hazards and the severity of sea conditions, it is clear that "Reduced Visibility" is a very severe problem at this site and merits a rating of "1. Overriding Significance."

Given the severity of this threat a number of things are needed to reduce the threat and provide safe passage. First, hazards must be marked with luminous and aural signals (bell buoys, whistle buoys). Moreover, since we know that a large number of the Category II vessels carry radar even if they do not meet the Category I requirements, it is advisable to ensure that all buoys used are good radar targets (this can involve adding radar reflectors to spars used in winter).

Providing lighted markers with sound signals on all relevant hazards might be sufficient if it were not for another problem. Here we must anticipate and note that Ice and Freezing Spray are "Highly Significant" threats (#8). The buoys have to be removed in the winter months and only one of these can be, and is, replaced with ice spar, which is not lighted and does not carry sound signal. On the other hand, the AES data table "Percentage and Frequency of Visibility and Good Shipping Weather", the incidence of reduced visibility is much lower in the winter months. Thus some additional system features are needed that continue to operate during the winter months. However, these do not have to be as effective in addressing the threat of reduced visibility as those operating during the rest of the year. Distinct lighted markers for position (land-based) are required. A land-based aural signal (distinct aural signal for direction) could be useful, but may not be necessary if all relevant hazards are marked with sound signals during the worst months of the year.

Concerning local means for addressing the threat of reduced visibility, once again we must note that given the proximity and number of hazards and the poor charting, local knowledge may be necessary for fully safe operation at this site. If all the traffic were local, mariners' knowledge of the site might reduce the overall requirement for aids to achieve safe operations. However, outsiders do come here and some of these have got themselves into trouble. In this respect the poor charting adds to the need for aids more than the general use of local knowledge subtracts from this need. With a better (larger scale) chart it might be possible to make the site safe for navigation with fewer aids or at least at less cost.

To meet the identified needs, Buoys QB1 and Q34 are lighted bell buoys marking hazards and Colombier Island Lightstation provides a distinct lighted marker for position all through the year. There is also a fog-horn at this lightstation which might be redundant if hazard marking were improved with added sound buoys. This would depend on the results of the operational analysis which would also take into account the requirements of availability and coverage for landfall.

4.7.7 Darkness

At this site, all the Category II vessels operate during the hours of darkness, (see Site Data Sheet). This category accounts for the vast majority of the vessels using the area.

Under some conditions, the standard practice of marking buoys with light reflective material could be considered sufficient to enable night-time operation of Category II vessels (assuming prudent operations of vessels equipped with searchlights). However, conditions here are not benign. The proximity and number of hazards, the sea conditions, and the incidence of reduced visibility (which compounds problems of darkness) make night-time operations at this site a very difficult problem. Thus, this merits a rating of "1. Overriding Significance" for Category II users.

Given this degree of threat, lights are needed on the hazard markers in addition to the reflective material. For the reasons noted above, it is also advisable to ensure that all buoys at the site are good radar targets. With lights on the buoys, if it were not for problems of winter (ice-season) operations, a distinctive lighted land-based marker for position might be redundant, but, given the requirement for operating in darkness when the buoys have been replaced by ice spars, this provision is necessary.

As previously noted, the requirements for lighted markers for hazards is met, in part, by Buoys QB1 and Q34, although there appears to be a need for a lighted marker for Wreck Island as well as some improvement in the marking of Bad Neighbour. Colombier Island Lightstation meets the need for a distinct lighted marker for position (land-based) for winter operations.

4.7.8 Ice and Freezing Spray

As previously noted, those knowledgeable about the site rate this threat as "Highly Significant" for Category II users (it is assumed that pleasure craft vessels, Category III, will not put to sea when ice or freezing spray are threatening). The major impacts of this threat have already been discussed above (4.7.6 and 4.7.7). Colombier Island Lightstation, and the ice spar placed to mark Twin Rocks in winter, address this threat.

4.7.9 Channel Siltation

As noted on the Site Data Sheet there is no channel siltation here. Therefore, this threat is not relevant.

4.7.10 Lack of Distinctive Features

None of the shoreline or other natural features are sufficiently distinctive to be used for positive identification of position. Thus this threat is "Significant". The first two types of markers on the list of those that can be used to address this threat are "Distinct visual markers for position" and "Visual markers on relevant hazards". Given the level of threat, either might be adequate but given that they are also required to reduce other threats, both are appropriate. Previous remarks about local knowledge, aids provided and additional requirements also apply here.

4.7.11 Summary of Comments from Example

The comparison of needs with what aids have been provided can be summarized as follows:

(a) Hazard marking at this site appears inadequate.

(b) A marker seems to be needed for Wreck Island. While a lighted buoy with a sound signal, light-reflective material, and good radar reflecting capabilities would be ideal, it is doubtful that a buoy could be kept on position of this location and, in any event, it would have to be removed for winter. Thus it might be necessary to settle for a permanent structure with a light-reflective mark and a radar reflector.

(c) While Buoy Q34 seems to provide adequate warning for those coasting past the site to stay away from Bad Neighbour, this buoy may be too far away from the hazard to be an adequate marker for those entering the site and heading to shore.

(d) If additional sound buoys are added to the system at Wreck Island and near Bad Neighbour, the fog horn at Colombier Island might be redundant.

These comments are, of course, not definitive since they are based only on a "desk-top" analysis. They are only intended to provide questions that should be addressed in the next stage of the review, Operational Analysis which includes consultation with users.

5. OPEN WATER SYSTEM DESIGN: LANDFALLS AND HAZARD MARKERS

5.1 General Considerations

In the previous chapters we have specified procedures for acquiring the basic data needed to design and review short-range marine aids systems, to rate the threats to navigation at the site, and to identify navigational needs for general types of markers and signals. The final step is operational analysis of site-specific requirements. Because of the differing basis for requirements for open and confined waters, these two types of areas will be considered separately.

An open water aids system is intended to assist the mariner to make safe landfall from open water and to move safely through the outer, open water approaches to a harbour or channel. Thus in designing such a system the primary concerns are the location, type and size of aids required to allow the mariner to confirm (or correct) the calculated or assumed position of the vessel and to avoid intervening and en route hazards. However, other needs may also be involved (e.g. to mark a pilot boarding station, a turn, an alternate route).

This chapter sets out the procedures for operational analysis of open water short-range marine aids systems to determine the specific requirements for aids to provide landfall, to mark intervening and en route hazards, and to meet other identified needs.

5.2 Documentation and Reference

The forms and reference documents required to conduct this operational analysis are:

(1) Directive 2-2200: "Design of Short-Range Marine Aids Systems".

(2) Copies of the charts of the area (multiple copies may be needed of the sections showing the site on both the large scale and small scale charts).

(3) The completed Site Inventory Forms (Section 2.2).

(4) The completed Site Data Sheet (Section 2.4).

(5) The monthly tables showing "Percentage Frequency of Wind Speed by Direction" from the AES data tables "Marine Climatological Summaries" for the site.

(6) The completed Preliminary Threat Rating Form (Section 3.4).

(7) The completed Needs Analysis Matrix (Section 4.2-4.6).

(8) Definition of Navigational Needs and Short-Range Aids Selection Matrix (p. 4-9 to 4-13).

(9) Visual and Radar Range of Buoys (Appendix A, Table A.1).

(10) Conversion Table for Height to Geographic Range (Appendix A, Table A.2).

(11) Effective Intensity of Lanterns (Appendix A, Table A.3).

(12) Determination of Nominal Range from Luminous Intensity (Appendix A, Table A.4).

(13) Conversion Chart for Nominal Range to Luminous Range under Various Visibilities (Appendix A, Figure A.1).

(14) General List of Fog Signals (and Nominal Range) (Appendix A, Table A.5).

(15) Determination of Nominal Range of Sound Signals (Appendix A, Figure A.2).

(16) Wind Effect on Audible Range of Selected Fog Signals (Appendix A, Figure A.3).

(17) Bouy Light-Flash Characteristics (Appendix A, Table A.6).

(18) Standard Daybeacons - Size Selection, Daymarks for Single Lighted Fixed Aids and Range Daymarks (Appendix A, Table A.7 and Figures A.4 and A.5).

(19) Landfall Design (Appendix C).

In addition, the manuals and standards listed in the Selected References can be informative and useful in this process.

5.3 Basis of Design

5.3.1 Landfalls

The need for landfall marking at a particular site is identified in the Needs Matrix in the column "Navigational Needs" as a "Distinctive visual marker for position." The need to have this lighted and/or supported by sound or radar signals may have been identified by the Needs Analysis. Sound or radar signals may also be required to meet the Design Availability level specified for the various types of traffic in the directive "Design of Short-Range Marine Aids Systems." Thus where visual aids and local means (e.g. natural land marks, lights on docks) do not cover the necessary visual range with distinctive markings for landfall the season, sound and/or radar signals may be added, according the categories of vessels involved, to achieve at least this level of service.

Other principles set out in this directive must also be taken into account in conducting an operational analysis.

Where there is more than one type of user, landfalls are normally designed to meet the needs of Local Commercial or Pleasure Craft users. This is because these users have the least navigational capabilities in terms of equipment and training. Category I (Long-Range Commercial) users are normally expected to make landfall by electronic means. Thus the means provided for Category II and III landfalls are usually more than enough for Category I users to confirm their position. However, this must be verified in the analysis because in some cases (especially where sound signals are involved) the landfall features do not meet the more stringent requirements for Design Availability for Category I users and a distinct radar signal may be needed for this purpose.

5.3.2 Marking of Hazards

The need for hazard markers in the outer approaches is noted in the Needs Analysis. The need to have these lighted and/or supported by sound or radar may also have been identified at this stage. Moreover, light, sound or radar signals may be necessitated by the determined Perception Requirements and specified Design Availability levels. Thus, where unlighted aids and natural features do not provide sufficient visual warning the specified minimum percentage of time during each month of the navigation season, light, sound or radar signals may be added, according to the categories of vessels involved and the principles specified in the directive "Design of Short-Range Marine Aids Systems".

While likely locations for hazard markers at any site are identified in the Needs Analysis, these are impacted by landfall design in two ways.

First, where hazards exist between the vessel routes/positions and the landfall aid they are considered relevant and should be marked with lighted or unlighted markers, sound and/or radar signals according to the Perception Requirements and the requirements for Design Availability. Hazards that are not directly between the landfall light and the normal route of the users shall also be considered as relevant if they are within the landfall Perception Gate. (see Appendix C).

Second, where hazards in the outer approaches are to be marked, the buoy light requirements are to be considered part of the landfall light provisions and, where possible, consideration is to be given to the various types of buoys; e.g., the use of a cardinal rather than a lateral buoy may achieve the extra light coverage required to allow the level of service to be met with a smaller shore light, or with a fairway buoy rather than a shore light.

5.3.3 Special Markers

The Needs Analysis may also identify special requirements (e.g., marker for a pilot boarding station, turn indicator in a complex passageway, marker for an alternative route, port of refuge or anchorage). The Needs Analysis itself may show that such markers should be lighted, have a sound signal, or incorporate a racon. Alternatively, such features may be necessary to meet the specified Design Availability levels in accordance with the principles set out in the directive "Design of Short-Range Marine Aids Systems".

The placement of such markers may have an impact on the landfall design. Given that special markers are necessary in any event, they may serve, as is or with minor upgrading, to meet the needs for landfall in whole or in part.

5.4 Operational Analysis Procedures

5.4.1 Overview

The operational analysis for the design or review of an open water short-range marine aids system is conducted in a series of steps, as follows:

(1) Prepare copies of the relevant charts showing traffic paths (see p. 4-8). Ensure that all existing aids are properly located on the charts. From the Needs Analysis, add to the charts likely locations for any necessary additional special markers or hazard markers.

(2) Calculate the necessary Perception Requirement (P) and mark the Perception (or Landfall) Gate (G) on a copy of the relevant charts.

(3) Calculate the required coverage (Perception Requirement) for any aids needed for special markers and hazards.

(4) Select aids to meet Perception Gate requirements in daylight conditions or review existing aids against these requirements.

(5) Calculate the required sizes of lights for landfalls and other purposes.

(6) Select lights or review any existing lights against these requirements.

(7) Examine combination options for lights (e.g., the use of lights on special markers or hazard markers for landfall).

(8) Review coverage of all (possible) lights against requirements and:

(a) If one or more of the above options meets the Design Availability requirements for landfall and other purposes under both daylight and darkness conditions, any sound signals and radar aids are redundant and should be noted as such; proceed to step (15).

(b) If none of the above options meets the Design Availability requirements for landfall and other purposes under both daylight and darkness conditions, proceed to step (9).

(9) Identify needs for radar aids to meet needs and Design Availability requirements.

(10) Identify needs for sound signals to meet needs and Design Availability requirements.

(11) Calculate the required size of fog signal for landfall.

(12) Examine combination option for sound signals (e.g., the use of bells or whistles on special markers or hazard markers for landfall).

(13) Examine impact of radar aids and sound signals on the need for lights and on the size of lights needed.

(14) Finalize optimal system design.

(15) For review purposes, compare optimal system with existing system, and make appropriate observations and recommendations.

Steps (2) to (15) are set out in more detail below.

5.4.2 Calculation of Landfall Coverage Required

Using the guidelines in "Design of Landfall", Appendix C, calculate the "Landfall Gate" or aids to navigation Perception Requirements (P). This will be based on the use of a non-standard compass where Category II or III vessels are involved, or on the use of radar where only Category I vessels are involved. This Perception Requirement or aids coverage required for safe landfall becomes the minimum geographic, luminous, aural or radar range required of any aids provided for making landfall from open water in daylight or in darkness, in good or poor visibility conditions, by sight, sound or radar.

The coverage required for successful landfall is calculated on the total of the radius of the circle of error of the vessel and any unmarked danger area around the landfall point, plus a safety margin.

The radius of error is calculated according to the guidelines for radar landfall when the aids system is for long-range commercial users only. Whenever the landfall system is for the local commercial or pleasure craft, guidelines for calculation of radius of error for non-standard compass are to be used. The needs of any long-range commercial users will also be met.

The danger area is the distance from the light to the farthest edge of any unmarked relevant hazard between the vessels approach and the landfall light. When the landfall is on a fairway buoy, this measurement should be zero. When all relevant hazards are marked, this measurement will be zero.

The safety margin is to be based on vessel size and manoeuvrability and shall have the values shown in column B for "Visibility" on the Preliminary Threat Rating Form.

5.4.3 Calculation of Coverage Required for Other Aids

All aids falling within the Perception (or Landfall) Gate are part of the landfall system and the necessary coverage is to be calculated as part of, and in the same way as, landfall requirements. This also applies to aids beyond the Perception Gate but proximate to standard routes, although this may only apply to certain classes of vessels or modes of entry to the harbour waterway. Aids which do not form part of the basic landfall system at a site but which mark pilot boarding stations, ports of refuge, alternative routes or anchorage will normally have to be treated as landfalls and the Perception Requirements determined accordingly. The Perception Requirement for other aids at the site (i.e., which are not part of a landfall system) is based upon vessel manoeuvrability and therefore the minimum coverage required is the value shown for the largest vessels using the site in Column B for "Visibility" on the completed Preliminary Threat Rating Form.

5.4.4 Daylight Coverage

To select appropriate aids or determine whether existing aids meet Perception Requirements under good visibility conditions, refer to Appendix A, Tables A.1 ("Visual and Radar Range of Buoys"), A.2 ("Conversion Table for Heights to Geographic Range"), and A.7 ("Standard Daybeacons - Size Selection"). In applying this information it should be noted that:

(a) The stated visual and radar ranges of buoys are based upon relatively calm seas. High waves obscure buoys and interfere with radar. Where the Site Data Sheet shows that high waves are frequently a problem, larger buoys and/or fixed aids may be required. Twenty-four hour lights on buoys might be considered to help overcome this problem.

(b) Where landfall lights are kept on for twenty-four hours, this supports the daymark capabilities of aids and normally overcomes any deficiencies in range.

(c) Problems of restricted visibility and night-time navigation must be borne in mind and, thus, when selecting or reviewing aids for sites used by Category I vessels or Category II vessels known to use radar to assist navigation, particular attention should be paid to designing and using aids which provide good radar targets.

The visual coverage provided by aids systems during daylight should meet the specified Design Availability requirements for the categories of vessels using the site. To determine whether the aids meet these requirements refer to Directive 2-2200 ("Design of Short-Range Marine Aids Systems") and to the completed Site Data Sheet. The directive states the Design Availability level for each vessel category and the Site Data sheet shows the categories using the site and the frequency of various degrees of visibility. The level of visibility must be equal to or greater than the required perceptual range for at least the minimum percentage of time specified as Design Availability. Where this does not occur, radar and/or sound signals are needed (see 5.4.9 to 5.4.12).

5.4.5 Calculation of Light Size

Where the Needs Analysis and/or the specific policies set out in Directive 2-2200 ("Design of Short-Range Marine Aids Systems") specify that lights are to be provided, the next step in the operational analysis is to determine the required size for each light, or the effective intensity as expressed in candelas.

The procedures or steps to determine the required light size are:

(a) Visibility Requirements

Using the Site Data Sheet, Item (5) "Visibility" establish the meteorological visibility level to be used for the design of lights. Select the visibility level that corresponds to the specified Design Availability (a) for Local Commercial users, if any; or (b) for Pleasure Craft users; or (c) if none of the foregoing use the site, for Long-Range Commercial users. (e.g., if the applicable level of Design Availability is 75%, then the corresponding visibility level is the highest level that occurs 75% or more of the worst month of the navigation season.

(b) Nominal Range

Using the "Conversion Chart for Nominal Range to Luminous Range Under Various Visibilities" (Appendix A, Figure A.1) identify the point at which the Design Visibility curve intersects the Luminous Range scale that is equal to the calculated Perception Requirement. The point where these lines intersect identifies the nominal range required.

(c) Luminous Intensity

Using the table that identifies the nominal range for a given luminous intensity (Appendix A, Table A.4), select the luminous intensity that most closely relates to the nominal range required.

(d) Lantern Size

Using the luminous intensity and the table for the various available lanterns (Appendix A, Table A.3) , the appropriate bulb and lantern size, colour and flash duration can be selected.

5.4.6 Reviewing Existing Light

The procedure outlined in 5.4.5. can be reversed to determine if the existing light provides the required coverage (Perception Requirement):

(a) Identify the candle (luminous intensity) output of the light.

(b) Determine the nominal range.

(c) Convert the nominal range to luminous range for the meteorological visibility level that corresponds to the specified Design Availability.

(d) Compare the luminous range to the calculated Perception Requirement (P).

5.4.7 Examination of Options (Lights)

Whether or not the landfall light coverage requirements can be met with a single shore light, alternatives must be examined to ensure cost effectiveness. The most obvious alternatives are:

(a) More than one shore-based light.

(b) A combination of lighted buoys and shore light(s).

(c) Coverage of the landfall gate with only lighted buoys.

In seasonal areas where lighted buoys are removed for the winter and navigation continues, the lighted buoy option without shore lights obviously would not meet the requirements for landfall coverage. In such circumstances, sizing of the shore light would be based on visibility levels for the winter season. The technical tables in Appendix A, and more specifically Tables A.1, A.3 and A.6, should be used to select appropriate buoys.

Identify those options which meet the perception requirements for landfall and for marking hazards, etc., and determine which is the most cost effective. If none of the options meet all requirements, identify those which most nearly do so and which among them is the most cost effective.

5.4.8 Determination of Further Requirements

Review daylight and darkness coverage provided under the identified options. If one or more of the options meets all visibility requirements, proceed to 5.4.14. If none do, additional types of aid features are required to meet the specified level of Design Availability, as set out in sections 5.4.9 to 5.4.13.

5.4.9 Radar Requirements

At sites where Category I (Long-Range Commercial) vessels operate and potential configurations of lighted and unlighted visual markers alone cannot meet the requirements for Design Availability, radar targets and/or signals are to be used to meet these requirements.

For radar landfalls, the requirements for a distinctive marker for positive identification of position normally can only be met by a racon. However, in some situations natural features and/or aids structures, alone or enhanced by radar reflectors, may provide a sufficiently distinctive image for positive identification. This can only be assessed and confirmed by local knowledge.

For hazard marking, aids structures, alone or enhanced by a radar reflector, are usually adequate radar target to provide the necessary warning. Where radar returns are confusing and precise knowledge is necessary, a racon may be deemed essential. Only local knowledge can make this judgement.

Where there is a significant volume of Category II users who are known to use radar, aids should be selected with this in mind and should be enhanced with a radar reflector where this is advantageous. The need for good radar targets for landfall, and to avoid hazards, is normally identified in the Needs Analysis process.

5.4.10 Requirements for Sound Signals

According to the level of service policy, sound producing devices may be added to the aids system to achieve the minimum system availability for the Local Commercial user where this cannot be achieved by unlighted and lighted visual means alone. Thus, where appropriate, sound signals should be added for landfall, hazard marking or other purposes when and where the available lights and visual markers cannot achieve the specified Design Availability for daylight and darkness conditions.

Ideally, the sound signals should cover the Perception Requirement needed for lights. Note that since sound signals are provided to meet the needs of Category II users, the necessary radius of coverage would be that needed for the largest Category II user; i.e., for hazard markers, etc., it would be the value in the Preliminary Treat Rating Form for the largest Category II vessels in Column B under "Visibility".

5.4.11 Determination of Requisite Fog Signals

While sound signals are not adversely affected by darkness, fog, etc., they are adversely affected by wind. Thus the selection and assessment of appropriate sound signals must not only take into account their nominal range, it must also take into account the effects of winds blowing against the intended direction of sound propagation and thereby limiting the actual coverage. Unfortunately relatively little operational data is available at this time on the effects of wind on marine aids sound signals. Some data for fog horns has been collected that can be used as a guide to inform judgement on the effects and requirements. No data is available, as yet, on buoy bells and whistles. Thus, the effects of wind on the coverage of sound from these aids can only be estimated with cautious judgement.

The first step in considering sound signal requirements is normally to look at the coverage that is or can be provided by a fog horn. Fog horns are used primarily to assist landfall, but can also be used to warn of hazards provided the sound covers the necessary distance beyond the hazard even under adverse wind conditions. The use of buoy bells and whistles is considered in the next section dealing with options.

The following steps will assist in determining the size requirements for fog horns intended to assist landfall and provide warning of intervening hazards.

(a) Using the AES datatable "Percentage Frequency of Wind Speed by Direction" for the month when visibility is most frequently restricted, establish the relevant wind speed level against the existing or proposed site from the horn that corresponds to the specified Design Availability level, i.e., 75% for Category II vessels. This would be the combined (summed) frequency of the highest wind speed blowing from within 45° on either side of the landfall path toward the horn that is exceeded no more than 25% of the time. (e.g., If the horn is to be located to the North East of the vessel making landfall, the relevant wind directions blowing the sound away from the vessels are South, Southwest and West. Assuming the combined average frequency of winds at the site from these directions during the month of worst visibility conditions to be at 0 to 4 knots or more 30.8% of the time, 5 to 9 knots or more 24.1% of the time, and 10 to 14 knots or more 16.5% of the time, then 9 knots is the relevant against-the-signal windspeed whose combined frequency is closest to, but not more, than 25% of the time).

(b) Using the graph "Wind Effect on Audible Range of Selected Fog Signals", an appropriately sized fog signal can be selected to cover the necessary area for landfall and hazard warning, or an existing fog signal can be rated against the necessary coverage.

5.4.12 Examination of Options (Sound)

It may be necessary to add sound signals to buoys in an open water short-range marine aids system to mark hazards or special features, or to provide the required coverage for landfall. At present, the actual coverage provided by bells and whistles is a matter of local judgment (because there is as yet, no operational data). In any event the use of bell buoys and whistles buoys can effect the size of fog horn needed or even obviate the need for a fog-horn.

At this point, if there are any alternative configurations of sound signals, these should be examined to see which one or ones best provide the coverage required at the least cost. Note that where buoys are seasonal and removed while navigation continues over winter, a shore-based fog horn may be needed for winter coverage. This would depend upon visibility conditions during the winter months.

5.4.13 Comprehensive Examination of Options

The addition of necessary radar and sound signals can affect the need for lighted aids at a site, or at least the size of lights needed. At this stage, the options for lighted features, for radar features and for sound features have each been examined individually. Now, the combined effects of all features should be examined to minimize redundancies and identify the combination of aids that best meet needs and the specified levels of Design Availability at the least cost. User inputs are essential in this final stage in order to confirm or revise the results of "desk-top" analyses.

5.4.14 Finalization of Design

After this comprehensive review of options has been completed, an optimal, cost-effective design for the site should be selected and the details specified.

5.4.15 Comparative Review

Where this exercise has been undertaken in order to review an existing short range marine aids system, the optimal and existing systems can now be compared and pertinent observations recorded. When there are significant differences, recommendations can be made for changes, taking into account costs and benefits (note that, for example, even though some aids could be downgraded, the costs of such changes might far outweigh any potential benefits).

5.5 Open Water System: Operational Analysis Example

An example operational analysis for the Burnt Island site in Newfoundland is being prepared and will be added to this manual.

6. CONFINED WATER SYSTEM DESIGN: PILOTAGE AND POINT-TO-POINT NAVIGATION

6.1 General Considerations

Chapter 5 outlined the procedures for operational analysis of open water short-range marine aids systems as the final analytical step in the design or review of such systems preparatory to user confirmation and review by local management and the review committee. This chapter outlines the equivalent procedures for confined water systems.

A confined water aids system is intended to assist the mariner to proceed safely through straits, channels, rivers, seaways, and the inner approaches to harbours. The normal method of guiding vessels through these waters is known as pilotage. In this mode of operation frequent or continuous information is needed from natural features or marine aids to indicate safe waters, locate hazards and direct necessary course alterations. Thus the primary concerns in designing such a system are the location, type, output and size of aids needed to delineate safe channels, including the appropriate spacing between markers. However, such areas may include open stretches where the provision of secondary landfalls is sufficient to allow point-to-point navigation, which is the alternate method of guiding vessels through these waters.

6.2 Documentation and Reference

The forms and reference documents required to conduct this operational analysis are:

(1) Directive 2-2200, "Design of Short-Range Marine Aids Systems".

(2) Copies of the charts of the area (copies will be needed of the section showing the site on the largest scale chart available; if only a small scale chart is available, an enlargement may be needed).

(3) The completed Site Inventory Forms (Section 2.2).

(4) The completed Site Data Sheet (Section 2.4).

(5) The monthly tables showing "Percentage Frequency of Wind Speed by Direction" from the AES "Marine Climatological Summaries" for the site.

(6) The completed Preliminary Threat Rating Form (Section 3.4).

(7) The completed Needs Matrix for Inner Approaches/Confined Waters (Sections 4.2 - 4.6).

(8) Definition of Navigational Needs and Short-Range Aids Selection Matrix (p. 4-9 to 4-13).

(9) Visual and Radar Range of Buoys (Appendix A, Table A.1).

(10) Effective Intensity of Lanterns (Appendix A, Table A.3).

(11) Determination of Nominal Range from Luminous Intensity (Appendix A, Table A.4).

(12) Conversion Chart for Nominal Range to Luminous Range (Appendix A, Figure A.1).

(13) General List of Fog Signals and Nominal Range (Appendix A, Table A.5).

(14) Wind Effect on Audible Range of Selected Fog Signals (Appendix A, Figure A.3)

(15) Buoy Light Flash Characteristics (Appendix A, Table A.6).

(16) Standard Day Beacons - Size Selection, Daymarks for Single Lighted Fixed Aids, and Range Daymarks (Appendix A, Table A.7 and Figures A.4 and A.5).

(17) Night-time Visibility Range of Reflective Marks and Buoys Using Hand-Held and Boat-Mounted Lights (Appendix A, Table A.8).

(18) Landfall Design (Appendix C).

In addition, the manuals and standards listed in the Supplementary References can be informative and useful in this process.

6.3 Basis of Design

The needs for navigational markers to assist safe passage through confined waters are identified on the Needs Matrix for Inner Approaches/Confined Waters. General guidelines can be given for the design of these systems but precise rules would be inappropriate, given the extreme differences in the conditions of such waterways across Canada. Professional judgement and local knowledge must be applied by designers and reviewers to ensure that systems of aids are safe and appropriate.

Aids to navigation systems must be designed to meet the needs of all users and, thus, from a safety perspective, must be designed to meet the needs of the least capable of these users. In the more open stretches where navigation is point-to-point by compass, the least capable are the Category II and III users who have less equipment, less accurate equipment and, normally, considerably less formal training than Category I users. In the more confined stretches where vessels are directed by pilotage, the least capable are the largest vessels because they require the greatest distance for manoeuvring and therefore need earlier warning of hazards and changes in the channel. Thus, where point-to-point navigation is involved, aids systems must be designed to accommodate the lesser accuracy of Category II and III users, if any. Where pilotage is involved, aids systems must be designed to accommodate the lesser manoeuvrability of the largest users.

Channel marking systems must keep mariners a safe distance away from hazards, including other vessels, and provide sufficient notice for the vessels to manoeuvre to avoid hazards and follow the basic route. Except where natural and local markings are sufficient, aids systems must also provide mariners with frequent or even continuous information to pilot their way along the route. Where conditions are sufficiently threatening (because of multiplicity of hazards, frequency of adverse weather and sea conditions, narrowness and complexity of the channel, etc.) sequential aids must be visible one from another, at least the percent of time specified by the applicable rate of Design Availability. Where conditions are less threatening, it may be adequate to space the aids so that navigation by compass bearing will allow markers to become visible before normal vessel position error could result in a significant threat to the vessel.

While landfall markers are usually equipped with 24 hour lights, this is not true of channel markers. Markers for segments of channels used by Category I (Long-Range Commercial) vessels during hours of darkness will be fitted with a sunswitch and lit for night-time use. For channels or segments of channels used only by Category II vessels during hours of darkness, the use of searchlights in conjunction with the reflective material on channel markers is considered adequate except where there are very serious threats, as identified in the Needs Matrix. Thus channel marking systems are designed first as daylight visual systems to which lights may or may not be added. Radar aids and sound signals may be added for Category I and II users respectively, where visual means alone do not meet the design criteria.

Therefore, the design criteria against which aids systems for confined waters must be tested are as follows:

(1) Perception requirements for point-to-point (secondary landfall) navigation marks in confined waters must be designed to accommodate the navigational accuracy of Category II and III users, if any, and, otherwise, that of Category I users.

(2) Hazard markers in landfall areas must provide sufficient coverage to allow the largest user time to complete an evasive manoeuvre.

(3) Where conditions are sufficiently threatening, sequential channel markers must be no further apart than the lowest visual range of the pair and must be close enough to each other to meet the Design Availability specified for the largest users of the site. For

less threatening situations, spacing of markers must at least meet the standards in (1) and (2) for point-to-point navigation.

(4) Markers for hazards and turning points in a channel must provide sufficient coverage to allow the largest users sufficient time and room to complete a manoeuvre.

Where different configurations of aids meet the minimum design requirements, final selection will be made in terms of cost-effectiveness.

6.4 Operational Analysis Procedures

6.4.1 Overview

The operational analysis for the design or review of a confined water short-range marine aids system is conducted in a series of steps:

(1) Prepare copies of the relevant charts showing traffic paths (cf. p.2-10). Ensure that all existing aids are (properly) located on the charts. If there is a landfall marker within the harbour or waterway, note the Perception Requirement and Gate on the chart (see Chapter 5 and Appendix C) and add any necessary additional aids for unmarked hazards within this gate. From the Needs Matrix for Confined Waters/Inner Approaches, also add to the chart likely locations for any additional special markers or hazard markers.

(2) Identify any segments of the traffic paths where point-to-point navigation is appropriate and secondary landfalls are required.

(3) Design secondary landfalls and test for adequacy.

(4) Determine relevant criteria.

(5) Examine potential options.

(6) Test options for marking channel with unlighted aids.

(7) Determine requirements for lights and test options.

(8) Determine requirements for radar aids and test options.

(9) Determine requirements for sound signals and test options.

(10) Test combination options to optimize cost-effectiveness.

(11) Finalize the optimum system design.

(12) If the system is under review, compare the optimum design with the existing system and develop appropriate observations and recommendations:

Steps (2) to (12) are set out in more detail in the next sections.

6.4.2 Point-to-Point Navigation Areas

Some inland waterways and inner paths of approach to harbours have long open segments than can be effectively and economically marked by providing aids for point-to-point navigation or secondary landfalls (e.g., an inner approach may pass between two islands or headlands but after this passage there may be several miles of wide, safe water before the harbour or harbour opening is reached; a river channel may open up for several miles before narrowing again to the point that channel demarcation is necessary). As long as vessels can safely navigate from point to point across these waters, provision of secondary landfall aids is appropriate.

To test the viability of the landfall option:

(a) Note the basic (straight) path of traffic across the area on the chart and add the calculated D.R. radial error (± 10% if any Category II or III vessels involved; otherwise ± 5% for Category I vessels).

(b) In the completed Preliminary Threat Rating Form note the value in the "Highly Significant" column (B) under "Distance from Hazard" for the largest vessels using the site, and add this margin of safety to either side of the path of travel (e.g., 400' for a 650' Laker).

(c) If any hazards fall within this path of travel, an alternative route and/or full channel demarcation should be used. Where the alternative route can be broken up into two or three relatively straight, long, safe segments, the use of a number of point-to-point markers (distinctive markers for position) may be appropriate.

(d) If the use of a point-to-point marking system still appears appropriate, now note the value for the largest vessels in the "Significant" column (A) under "Distance from Hazard" and add this to the cone-shaped path(s) of travel rather than the value from column B.

(e) Any hazards within this wider area must be marked; thus, if this area includes a number of hazards, consideration must be given to whether the hazard markers effectively delineate a channel in any event, and, therefore, whether point-to-point markers or a landfall light would really be redundant.

6.4.3 Design of Secondary Landfalls

Where a point-to-point marking system meets the above requirements, the design of these secondary landfalls is essentially the same as for open water landfall except that the entry point into the area is known since the vessels have been passing through a marked channel. The marker may be designed accordingly. Except for this small difference, the design of secondary landfalls follows the principles and procedures set out in Chapter 5 and Appendix C. Note that the rules for marking hazards in the Perception Gate also apply and that the precise design may be affected by the requirements for special markers within this segment of the route.

6.4.4 Channel Marking Criteria

In confined waters where secondary landfalls are not appropriate and natural and local markings are insufficient, marine aids must be used to denote channels. A number of criteria can be applied to the design of such channel-marking systems.

The first is the "Design Visibility", or the lowest level of visibility at which the system can be used visually. The necessary Design Visibility of a system is determined by the applicable Design Availability or the minimum percentage of time that the system must be usable during the worst month (for visibility) of the navigation season, as specified in Directive 2-2200, "Design of Short-Range Marine Aids Systems". The Design Visibility is the maximum distance of visibility that is available, on average, the required percentage of time during the worst month of the navigation season. To determine the Design Visibility for a site, find the average frequency of visibility shown in item (5) "Visibility" on the Site Data Sheet which corresponds to the specified rate of Design Availability (e.g., if only Category II and III vessel use the site, then the minimum Design Availability would be that the highest for the two, or 75%. Note that the policy allows a higher rate of Design Availability to be applied to specific sites where there is a high volume of traffic and associated economic benefits, and where local users demonstrate to CCG managers that there is a need for a higher rate of availability. Assuming that in this case there are no such special requirements, then, if 1/2 mile visibility or better occurs 87.6% of the time during the worst month, 1 mile visibility or better 76.2% of the time, and 2 mile visibility or better 69.4% of the time, then 1 mile visibility would be the appropriate Design Visibility).

Another factor which affects the design is the appropriate mode of navigation in particular segments of a channel. While a mariner might want to be able to see at least one marker or signal ahead when piloting through a channel, this is not always necessary. Particular segments of a channel may be sufficiently broad and trouble free that vessels can be expected to proceed, for a limited time, by dead-reckoning navigation. This situation is similar to secondary landfalls but involves more limited stretches of water.

Given that aids provided are to be the minimum necessary for the safe and expeditious movement of marine traffic, priority is to be given to marking channels in a way that requires the use of dead-reckoning navigation where it is appropriate to do so. To determine whether a particular segment of a channel may be safely marked in this fashion, first refer to the chart to see if there are any significant straight lengths of the channel where no hazards have to be marked (i.e., where none are closer to the central path of travel than the distance noted under the "Significant" column (A) of "Distance from Hazards" on the Preliminary Threat Rating form for the largest vessels using the site). Next make sure that neither the sea conditions nor the traffic density pose threats that are "Highly Significant" or of "Overriding Importance". The final test is whether mariners can navigate the necessary distance without ending up in a threatened position before the next marker is sighted. To test this use the procedures set out in Chapter 5 and Appendix C for testing landfalls. Note, however, that the daylight visual range of the markers at either end of the channel would have to be used as their range of coverage rather than the longer range of any lights because channel markers do not normally carry 24 hour lights.

The question of whether or not it is appropriate to require mariners to use dead-reckoning navigation along certain stretches of the channel affects the necessary distance between aids. Where piloting alone is to be used to guide the vessels, the maximum distance between aids along the channel would be the lesser of the Design Visibility or the Daylight Visual Range of aids that can be used* so that the mariner will be able to see at least one aid ahead for at least the percentage of time specified by Design Availability. Where it is appropriate to require the use of dead-reckoning navigation, the aids will be somewhat further apart.

A third factor to be taken into account is the necessary degree of warning for hazards along route. This is the minimum distance required for warning of the need to manoeuvre by the least capable vessels; i.e., the largest vessels using the channel. To determine this value, refer to the Preliminary Threat Rating Form and, in the row for the largest vessels using the site, find the value under "Visibility" in the "Highly Significant" column (B). This distance is the range of warning that must be provided for hazards along the channel by the Daylight Visual Range of the marker or other means where this is not sufficient to meet the requirements of Design Visibility and thus Design Availability.

In summary, the basic criteria affecting the design of channel marking aids systems are:

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* Note that it is possible to meet either one of these requirements without meeting the other. For example, buoys placed three miles apart could meet the visual range requirement if their Daylight Visual Range was four miles, but not the Design Visibility requirement if visibility was less than three miles more often than allowed under the specified rate of Design Availability. On the other hand if visibility was three miles or more a sufficient percentage of the time, but the Daylight Visual Range of the buoys was only two miles, this latter capability would not meet the requirements.

(a) Design Visibility, or the minimum level of visibility for which the system is designed to be used visually with normal caution and speed.

(b) Whether dead-reckoning navigation or piloting by direct observations is to be used for guiding vessels through a stretch of the channel.

(c) The necessary range of warning of hazards.

While the final criteria determines the range and coverage required for hazard markers, the first two conjointly determine the range and coverage required from other channel markers and the maximum allowable distance between markers. It should be noted, however, that the actual distance between markers may be considerably less than this maximum where there is a multiplicity of hazards, a complex and/or very narrow channel, a very high volume of traffic, etc.

6.4.5 Channel Marking Options

Several different configurations of aids can be used to denote channels:

(a) **Boundary Markers** are the most precise and complete mode of marking channels. They are usually required: (i) together with turn indicators, where channels are very complex; (ii) together with traffic separation, where there is a very high volume of traffic; and, (iii) in other cases where it is necessary or advisable to direct traffic along a specific route. Note that there may or may not be hazards in the waters beyond the boundary markers; these markers merely denote an area that is safe.

(b) **Hazard Markers,** by way of contrast, tell the mariner where it is not safe. Markers are required on hazards that are closer to the track than the relevant values shown in the "Significant" column (A) under "Distance from Hazard" in the Preliminary Threat Rating Guide. These markers may be sufficient to delineate the channel without additional aids.

(c) **Ranges** are probably the most precise although not the most thorough mode of marking channels. They denote a channel by giving the mariner a line of sight to follow. Ranges are normally required where there are problems of wind, waves and/or current. They are usually a necessity where navigation continues even though buoys have been removed for winter because of ice and icing conditions. They may be used as a low-cost method of denoting a channel, since one well placed shore-based range can replace the need for a series of boundary or hazard markers. One limitation is that a range can only be used by a few vessels at a time. Moreover, if hazards have not been marked it can be very dangerous if a range light goes out, or the range becomes invisible for any reason, because ranges have no back-up or secondary characteristics such as sound signals or radar images.

While each of these modes can be used alone, they can also be used in combination. The Needs Analysis conducted in completing the Needs Matrix will give an initial indication of the appropriate configuration. However, to be certain of requirements, it is essential to take into account the necessary coverage and visual range.

6.4.6 Reviewing Options for Daytime Use of System

As noted in the previous section, the options for delineating channels include the use of boundary markers. hazard markers and ranges, together with special features such as turn indicators. Each of the basic methods has advantages and limitations. One or more of these options will have been identified as a generic need in the Needs Analysis process.

In the Operational Analysis process the options must be tested for feasibility, operational adequacy and cost-effectiveness. To do this, it is first necessary to consider the appropriateness of the different options, then to determine whether systems which meet the criteria specified in section 6.4.4 can be designed for the site using appropriate modes and, finally, to select the most cost-effective of any options.

The advantages and disadvantages of the three methods linked to five types of problems: (a) lateral force; (b) hazard warning; (c) complex channel; (d) high volume of traffic; and (e) ice.

Winds, waves and cross currents can exert lateral force on vessels and cause "crabbing", where the vessel moves in a somewhat different direction than that in which it is headed. Under these conditions, it is difficult for the operator to know whether the vessel is actually moving in the intended direction. Some assistance is needed. The most effective assistance is a range which provides a line of sight to follow. Where provision of a range is not feasible (i.e., there is no appropriate and feasible location), boundary markers have to be used. These will at least warn the mariner when the vessel has drifted too far one way or another from the intended route. Hazard markers alone very seldom provide sufficient information for the mariner to keep the vessel on the intended track.

The three modes of delineating a channel provide different ways of avoiding hazards. Hazard markers give mariners warning to stay away from the vicinity of the hazards. Boundary markers tell mariners that as long as they stay within the demarcated area they are safe from hazards (or more precisely from unmarked hazards, because occasionally it is necessary to have a channel go where there is a few hazards). Ranges tell mariners that they are safe from hazards as long as they stay on the line of sight provided. Thus hazard markers are the only complete system of hazard warning and, in this sense, the best mode of hazard warning.

Where a channel is complex, (i.e., where multiple turns are necessary), hazard markers alone are unlikely to be sufficient to help the mariner keep on the appropriate path. If a very precise path must be followed or there is a strong current, one or more ranges are probably required. If there is two-way traffic and/or a high volume of traffic, boundary markers are usually also needed and may make the provision of a range or ranges redundant.

Ranges, however, have a limitation; they can only be used by, at most, a few vessels at a time. Thus, where the volume of traffic is high, ranges alone are not an appropriate way to mark a channel. When the volume of traffic becomes very high, traffic separation will be required, splitting the passage into two directional channels. Boundary markers are normally required to outline the parallel channels.

Land-based ranges do have an advantage; they are not affected by ice. Buoys marking hazards or boundaries have to be replaced by spars for the ice season. Spars have a much shorter visual range. The seasonal replacement also adds to the operating costs of the system.

Table 6.1 summarizes the advantages and disadvantages of the use of the different types of markers to delineate a channel.

Table 6.1
Applicability of Methods of Marking Channels

	Method of Channel Marking		
Problems:	Ranges	Hazard Markers	Boundary Markers
Lateral Force	Fully effective	Seldom adequate	Somewhat effective
Hazard Warning	Provides safe path only	Most effective	Provides safe area
Complex Channel	Can be effective	Insufficient	Can be effective
Volume of Traffic	Appropriate for lower volumes only	Appropriate for moderate and lower volumes only	Necessary for very high volumes of traffic
Ice	Very seldom affected	Buoys have to be replaced by spars	Buoys have to be replaced by spars

As can be seen from this table, boundary markers are most likely to be the most effective option for marking channels. Unfortunately, they are often the most expensive, requiring the greatest number of aids and aids with relatively high maintenance costs. Thus, alternatives have to be considered to see if they are adequate for the site and can meet the design requirements set out in 6.4.4.

If none of these options using only daylight visual markers meet the design requirements for daytime use, then it is necessary to consider adding 24 hour lights, radar aids and/or sound signals.

6.4.7 Channel Lights

As previously noted except where they are part of a landfall system, channel markers, are not normally lighted for daytime use and are only lighted for night-time use (a) along segments of channels regularly used at night by Category I users or (b) where needed for Category II night-time users because of the severity of threats.

Lights provided for use in channels during hours of darkness must meet the perception requirement and availability standards set out in section 6.4.4. That is, where point-to-point dead-reckoning navigation is appropriate, the nominal range of lights on sequential aids must allow the least capable mariners to navigate safely between them. Where piloting is essential, the perception area must be sufficient to at least cover the distance between the aids, and do so at least the percentage of time specified by the applicable rate of Design Availability. In addition, lights on turn markers or other markers where vessels may have to manoeuvre must provide at least the minimum warning time needed by the largest vessels for manoeuvring, again meeting Design Availability requirements.

The procedures or steps for determining the required size of lights are:

(a) Visibility Requirements

Using the Site Data Sheet, Item (5) "Visibility" establish the meteorological visibility level to be used for the design of lights. Select the visibility level that corresponds to the specified Design Availability (e.g., if the applicable level of Design Availability is 85%, then the corresponding visibility level is the highest level that occurs 85% or more of the time during the worst month. If the percent of time that visibility is less than .5, 1.1 and 2.2 nautical miles is 13%,24% and 42%, respectively, then visibility is equal to or better than .5, 1.1 and 2.2 nautical miles 87, 76% and 58% of the time, respectively. Thus, .5 nautical miles (87% of the time) is the corresponding visibility level for an 85% level of Design Availability).

(b) Nominal Range

Using the "Conversion Chart for Nominal Range to Luminous Range Under Various Visibilities" (Appendix A, Figure A.1) identify the point at which the Design Visibility curve intersects the Luminous Range scale that is equal to the Perception Requirement (required coverage). The point where these lines intersect identifies the nominal range required.

(c) Luminous Intensity

Using the table that identifies the nominal range for a given luminous intensity (Appendix A, Table A.4), select the luminous intensity that most closely relates to the nominal range required.

(d) Lantern Size

Using the luminous intensity and the various sheets for available lanterns, the appropriate bulb and lantern size, colour and flash duration can be selected.

This procedure can be reversed to determine if the existing light provides the required coverage:

(i) Identify the candelas (luminous intensity) output of the light.

(ii) Determine the nominal range.

(iii) Convert the nominal range to luminous range for the meteorological visibility level that corresponds to the specified Design Availability.

(iv) Compare the luminous range to the calculated perception requirement (required coverage).

Where channel markers are to be lit for night-time use and there are difficulties in meeting the required coverage and availability standards for daytime use, consideration should be given to using 24 hour lights. While the propagation of light in daytime fog is problematic, the use of a 24 hour light might extend the daytime range sufficiently to meet coverage and availability requirements.

6.4.8 Radar Aids for Marking Channels

The use of ship's radar to guide vessel movement in channels is often problematic because the radar returns are difficult to interpret (because of sea clutter, heavy traffic, low fore-shore, etc.). Therefore, where coverage and availability requirements cannot be met by visual means alone and there are radar-equipped vessels using the channel (Category I or others), aids to navigation selected to mark the channel should present good radar targets. Where it is difficult identify and to distinguish aids to navigation from other objects on the radar display, aids that are more conspicuous may be necessary (eg., gated pairs of buoys). Where there is Category I traffic, high risk hazards (e.g., bridges) may be marked with racons. Situations requiring radar aids for marking channels are normally identified in the Needs Analysis process.

6.4.9 Sound Signals for Marking Channels

Where coverage and availability standards cannot be met by visual means alone and there are a number of Category II users, sound signals should be added to attempt to meet requirements. There are, however, certain difficulties in doing so. Because channels are in confined water, wave action is limited and may be insufficient to activate bell buoys -- at least under still inland fog conditions. Where this is the case, electronic fog signals will have to be used. The following steps will assist in determining the size requirements for fog signals intended to provide secondary landfalls and warning of any intervening hazards:

(a) Using the AES datatable "Percentage Frequency of Wind by Direction" for the month when visibility is most frequently restricted, establish the relevant wind speed level, against the existing or proposed site from the horn, that corresponds to the specified Design Availability level, i.e. 75% for Category II vessels. This will be the combined (summed) frequency of the highest wind speed blowing from up to approximately 45° on either side of the landfall path that is exceeded no more than 25% of the time. (For example, if the horn is located to the North East of the vessel making landfall, the relevant wind directions blowing the sound away from the vessels are South, Southwest and West. Assuming the combined average frequency of winds at the site from these directions during the month of worst visibility conditions is 0 to 4 knots or more 30.8% of the time, 5 to 9 knots or more 24.1% of the time, and 10 to 14 knots or more 16.5% of the time, then 9 knots is the relevant against-the-signal wind speed whose combined frequency is closest to, but not more, than 25% of the time).

(b) Using the graph "Wind Effect on Audible Range of Selected Fog Signals", an appropriately sized fog signal can be selected to cover the necessary area for landfall and hazard warning, or an existing fog signal can be rated against the necessary coverage.

6.4.10 Comprehensive Examination of Options

Channel marking aids systems are designed primarily as daylight visual systems with lights, radar aids and sound signals added, as appropriate, to assist vessel operations during hours of darkness and restricted visibility. By this stage in the operational analysis, where available and applicable, options will have been examined, for these features (daylight visual range, lights, etc.)

individually. Now, the combined effects of all features should be examined to minimize redundancies and identify the combination of aids that best meets the needs and the specified level of Design Availability at the least cost. User inputs are essential in this final stage in order to confirm or revise the results of "desk-top" analyses.

6.4.11 Finalization of Design

After this comprehensive review of options has been completed, an optimal, cost-effective design for the site should be selected and the details specified.

6.4.12 Comparative Review

Where this exercise has been undertaken to review an existing short range marine aids system, the optimal and existing systems can now be compared and pertinent observations recorded. When there are significant differences, recommendations can be made for changes, taking into account costs and benefits (note that, for example, even though some aids could be downgraded, the costs of such changes might far outweigh any potential benefits).

6.5 Confined Water System: Operational Analysis Example

An example operational analysis of a confined waters short-range marine aids system is being prepared and will be added to this manual.

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SUPPLEMENTARY REFERENCES

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APPENDIX A

TECHNICAL TABLES AND FIGURES

TABLE A.1
VISUAL AND RADAR RANGE OF BUOYS

Class	Old Description	Old Dwg No.	New Metric Designator	Radar Rating (0-10)	Radar Range (N. Miles)	Daytime Visual Range (N. Miles)
1.	4' - 6" electric	CR-15006 (FA1001)	1.4 x 5.2 L	7-10	4-5	2-4
2.	6' - 0" electric	CR-15005 (FA-1004)	1.8 x 5.8 L	7-10	5-5	4.5
3.	9' - 6" Bell*	CR-15004 (FA-1007)	2.9 x 6.7 LB	10	7	3-4
4.	9' - 6" Whistle*	CR-15003 (FA-1010)	2.9 x 10.4 LW	10	7	3-4
5.	10' - 0" Scow	CR-15284 (FA-1015)	1.5 x 3.0 x 2.4 L	5		
6.	1.5m Discus	CR-15494 (FA-1019)	1.5 x 1.8 LD	7		
7.	2' - 6" electric spar	CR-15158	0.7 x L	5		
8.	2' - 6" to 3' - 0" can/con., coastal	CR-15001/2 (FA2001/2)	C-0.8 Cn, Sp, Cl.	7	3.5	0.9-1.0
9.	4' - 0" can\con, coastal	CR-15001/2 (FA2003/4)	C-1.2 Cn, Sp.	7		
10.	5' - 0" to 7' - 0" can/con, coastal	CR-15001/2 (FA2005/6)	C-1.6 Cn, Sp, Cl.	7		
11.	7' - 0" conical, coastal	CR-15002 (FA2007)	C-2.0 C1.	7		
12.	3' - 0" can/con., coastal	CR-14765 (FA2008/9)	C-0.9 Cn,Cl.	7		
13.	4' - 0" can/con., River	CR-14765 (FA2010/21)	R-1.2 Cn, Cl.	7	4	3.5
14.	24" can/con., River	CR-15356 (FA2012/13)	M-0.6 Cn, Cl.	7		
15.	8' - 0" Canol	CR-15291 (FA2014)	Fc-2.4 Cn, Cl	5		
16.	18" - can/con.	CR-15160 (FA2015/16)	M-0.4 Cn, Cl.	7		
17.	Small foam buoys, Barrels, Drums			5		
18.	3' - 3" ice spars, swift current	CR-14764 (FA3001/2)	1.0 x 9.9 1Cn, 1C1	5		
19.	2' - 3" ice spars, swift current	CR-15152 (FA3003/4)	0.7 x 9.4 1Cn, 1C1	5		
20.	long spars	CR-15253 (FA3005)	0.6 x 6.0 Cn, Cl.	5	2.5	1.5
21.	short spars	CR-15253 (FA3006)	0.6 x 4.0 Cn, Cl.	5		
22.	short spars, O.R.T.	AR15010 (FA3007)	0.3 x 2.3 Cn, Cl.	5	1	0.25
23.	fibreglass spars	(FA-3008)	0.18 x 3.0 Cn, C1.	0		
24.	stakes & bushes			0		
25.	wood spars			0		
26.	2' - 6" spars	CR-15158		5		

* Nominal ranges for buoy bells and whistles are not available. Until a study establishing such ranges, 1/2 mile shall be used.

• Nominal range of a bell will vary according to the design of the superstructure, bell clappers, etc.

Notes:

1. Radar Range and Daytime Visual Range are based on reported radar and visual ranges by C.G. officers during clear and calm weather.
2. For nightime visual range of unlighted buoys, (searchlight) when buoys are fitted with light-reflective standard marking and numbers, see policy element A31.

TABLE A.2

CONVERSION TABLE FOR HEIGHT TO GEOGRAPHIC RANGE

(HEIGHT IN FEET)

Height (feet)	Distance (nautical miles)	Height (feet)	Distance (nautical miles)
5	2.5	110	12.0
10	3.6	120	12.6
15	4.4	130	13.1
20	5.1	140	13.6
25	5.7	150	14.1
30	6.3	200	16.2
35	6.8	250	18.2
40	7.2	300	19.9
45	7.7	350	21.5
50	8.1	400	22.9
55	8.5	450	24.3
60	8.9	500	25.6
65	9.2	550	26.8
70	9.6	600	28.0
75	9.9	650	29.1
80	10.3	700	30.3
85	10.6	800	32.4
90	10.9	900	34.4
95	11.2	1,000	36.2
100	11.5		

(HEIGHT IN METRES)

Height (metres)	Distance (nautical miles)	Height (metres))	Distance (nautical miles)
2	2.9	55	15.4
3	3.6	60	16.1
4	4.2	70	17.4
5	4.6	80	18.6
6	5.1	90	19.7
7	5.5	100	20.8
8	5.9	120	22.8
9	6.2	140	24.6
10	6.6	160	26.3
12	7.2	180	27.6
14	7.8	200	29.4
16	8.3	250	32.9
18	8.8	300	36.0
20	9.3	350	38.9
25	10.4	400	41.6
30	11.4		
35	12.3		
40	13.1		
45	13.9		
50	14.7		

Example:

An observer whose eye is 50 feet above the water can see a light having an elevation of 120 feet above the water at a distance: 8.2 + 12,6 = 20.7 nautical miles.

Example:

An observer whose eye is 12 metres above the water can see a light having an elevation of 40 metres above the water at a distance: 7.2 + 13.1 = 20.3 nautical miles.

TABLE A.3

EFFECTIVE INTENSITY OF LANTERNS
(Candelas)

3.1 FOR LANTERNS: (a) Automatic Power Inc., FA-249, 155MM, acrylic lens
(b) Tideland Signal Ltd., ML-155, 155MM, acrylic lens

FLASH DURATION (SEC)		0.3	0.4	0.5	0.6	0.8	1	2	3	FIXED
LENS COLOUR	LAMP (12V)									
CLEAR	0.25A	27	31	34	36	39	41	45	46	50
	0.55A	60	71	79	85	91	97	108	112	120
	0.77A	90	108	119	126	137	146	162	166	180
	1.15A	117	146	164	179	195	208	234	242	260
	2.03A	195	255	300	330	370	390	445	465	500
RED OR GREEN	0.25A	8	9	10	11	11	12	13	13	14
	0.55A	17	21	23	25	26	28	31	32	35
	0.77A	26	31	34	37	40	42	47	48	52
	1.15A	34	42	48	52	57	60	68	70	75
	2.03A	57	74	87	96	107	113	129	135	145

NOTE: Intensity values for the 12V, 3.05A lamp are not listed here since this lamp, with its S-11 bulb, will not fit in the 155MM lantern when used in the standard six-place lampchanger.

TABLE A.3 (Cont'd)

EFFECTIVE INTENSITY OF LANTERNS
(Candelas)

3.2 FOR LANTERNS: Tideland Signal Ltd., ML-300, 300MM, acrylic lens

FLASH DURATION (SEC)		0.3	0.4	0.5	0.6	0.8	1	2	3	FIXED
LENS COLOUR	LAMP (12V)									
CLEAR	0.25A	54	63	68	73	78	82	90	93	100
	0.55A	130	153	172	185	198	211	234	242	260
	0.77A	200	240	264	280	304	324	360	368	400
	1.15A	247	308	346	379	413	440	495	511	550
	2.03A	409	535	630	693	777	819	934	976	1050
	3.05A		660	810	915	1065	1155	1335	1380	1500
	500W*			2990	3510	4290	4745	5720	5980	6500
	1000W*			6552	8064	10248	11592	14616	15456	16800
RED OR GREEN	0.25A	15	18	19	20	22	23	25	26	28
	0.55A	36	43	48	52	55	59	66	68	73
	0.77A	56	67	74	78	85	91	101	103	112
	1.15A	69	86	97	106	115	123	139	143	154
	2.03A	115	150	176	194	218	229	262	273	294
	3.05A		185	227	256	298	323	374	386	420
	500W*			837	983	1201	1329	1602	1674	1820
	1000W*			1835	2258	2869	3246	4092	4328	4704

NOTE: Heat load must not exceed 250 watts steady. This restricts 500W lamps to a 50% duty cycle and 1000W lamps to a 25% duty cycle.

*120V

TABLE A.3 (Cont'd)

EFFECTIVE INTENSITY OF LANTERNS
(Candelas)

3.3 FOR LANTERNS: Automatic Power Inc., FA-250, 250MM, acrylic lens

FLASH DURATION (SEC)		0.3	0.4	0.5	0.6	0.8	1	2	3	FIXED
LENS COLOUR	LAMP (12V)									
	0.25A	38	44	48	51	55	57	63	65	70
	0.55A	90	106	119	128	137	146	162	167	180
	0.77A	135	162	178	189	205	219	243	248	270
CLEAR	1.15A	180	224	252	276	300	320	360	372	400
	2.03A	300	393	462	508	570	601	685	716	770
	3.05A		462	567	640	745	808	934	966	1050
	500W*			2300	2700	3300	3650	4400	4600	5000
	1000W*			4407	5424	6893	7797	9831	10396	11300
	0.25A	13	15	16	17	19	20	21	22	24
	0.55A	31	36	40	43	47	50	55	57	61
RED OR	0.77A	46	55	61	64	70	74	83	84	92
GREEN	1.15A	61	76	86	94	102	109	122	126	136
	2.03A	102	134	157	173	194	204	233	243	262
	3.05A		157	193	218	253	275	318	328	357
	500W*			782	918	1122	1241	1496	1564	1700
	1000W*			1498	1844	2344	2651	3343	3535	3842

NOTE: The standard 250MM is limited to 75 watts steady. This restricts 500W lamps to15% cycles and 1000W lamps to 7.5% duty cycles. The 250MM high wattage can accept 200 watts steady - 40% duty cycle for 500W lamps and 20% duty cycle for 1000W lamps.

*120

TABLE A.3 (Cont'd)

EFFECTIVE INTENSITY OF LANTERNS
(Candelas)

3.4 FOR LANTERNS: DLD-200, 200MM, glass lens

FLASH DURATION (SEC)		0.3	0.4	0.5	0.6	0.8	1	2	3	FIXED
LENS COLOUR	LAMP (12V)									
CLEAR	0.25A	16	19	20	22	23	25	27	28	30
	0.55A	40	47	53	57	61	65	72	74	80
	0.77A	60	72	79	84	91	97	108	110	120
	1.15A	81	101	113	124	135	144	162	167	180
	2.03A	148	194	228	251	281	296	338	353	380
	3.05A		229	281	317	369	400	463	478	520
RED	0.25A	4	4	4	5	5	5	6	6	7
	0.55A	9	10	12	12	13	14	16	16	18
	0.77A	13	16	17	18	20	21	24	24	26
	1.15A	18	22	25	27	30	32	36	37	40
	2.03A	33	43	50	55	62	65	74	78	84
	3.05A		50	62	70	81	88	102	105	114
GREEN	0.25A	3	4	4	4	5	5	5	6	6
	0.55A	8	9	11	11	12	13	14	15	16
	0.77A	12	14	16	17	18	19	22	22	24
	1.15A	16	20	23	25	27	29	32	33	36
	2.03A	30	39	46	50	56	59	68	71	76
	3.05A		46	56	63	74	80	93	96	104

TABLE A.3 (Cont'd)

EFFECTIVE INTENSITY OF LANTERNS
(Candelas)

3.5 FOR LANTERNS: DLD-300, 300MM, glass lens

FLASH DURATION (SEC)		0.3	0.4	0.5	0.6	0.8	1	2	3	FIXED
LENS COLOUR	LAMP (12V)									
	0.25A	19	22	24	25	27	29	31	33	35
	0.55A	48	56	63	67	72	77	85	87	95
CLEAR	0.77A	95	114	125	133	144	154	171	175	190
	1.15A	117	146	164	180	195	208	234	242	260
	2.03A	249	326	384	423	474	499	569	595	640
	3.05A		330	405	457	532	577	667	690	750
	0.25A	4	5	5	6	6	6	7	7	8
	0.55A	10	12	14	15	16	17	19	19	21
RED	0.77A	21	25	28	29	32	34	38	39	42
	1.15A	25	32	36	39	43	45	51	53	57
	2.03A	54	71	84	92	104	109	125	130	140
	3.05A		72	89	99	117	127	146	151	165
	0.25A	4	4	5	5	5	6	6	7	7
	0.55A	10	11	13	13	14	15	17	17	19
GREEN	0.77A	19	23	25	27	29	31	34	35	38
	1.15A	23	29	32	36	39	41	46	48	52
	2.03A	49	65	76	84	95	99	113	119	128
	3.05A		66	81	91	106	115	133	138	150

TABLE A.3 (Cont'd)

EFFECTIVE INTENSITY OF LANTERNS
Candelas

3.6 FOR LANTERNS: FA-240 Range Lantern, Automatic Power Inc.

		LENS		
Lens Colour	Lamp (12v)	3.5° x 2.0° Plastic	8° Glass	30° Glass
CLEAR	0.25A	2,470	1,420	440
	0.55A	5,760	3,300	1,030
	0.77A	10,300	6,250	1,940
	1.15A	14,300	8,700	2,770
	2.03A	30,700	17,800	5,760
	3.05A	42,100	27,100	8,100
RED	0.25A	820	440	114
	0.55A	1,900	1,020	268
	0.77A	3,400	1,940	504
	1.15A	4,720	2,700	720
	2.03A	10,100	5,520	1,500
	3.05A	13,900	8,400	2,100
GREEN	0.25A	1,260	412	106
	0.55A	2,940	960	247
	0.77A	5,250	1,810	466
	1.15A	7,300	2,520	665
	2.03A	15,700	5,160	1,380
	3.05A	21,500	7,860	1,940

TABLE A.3 (Cont'd)

EFFECTIVE INTENSITY OF LANTERNS
(Candelas)

3.7 FOR ROTATING BEACON: Automatic Power Inc. FA-251

RPM		1	2	3	4	5	10	FIXED
LENS COLOUR	LAMP (12V)							
	0.55A	3,170 .12	1,990 .08	1,470 .06	1,160 .04	970 .04	530 .02	14,900
	0.77A	5,410 .14	3,460 .08	2,560 .06	2,040 .05	1,700 .04	940 .02	22,000
CLEAR	1.15A	7,450 .14	4,750 .09	3,540 .06	2,830 .05	2,360 .04	1,300 .02	30,500
	2.03A	16,700 .17	11,000 .10	8,300 .08	6,700 .06	5,650 .05	3,160 .03	59,500
	3.05A	20,300 .18	13,500 .11	10,200 .08	8,250 .07	6,950 .06	3,930 .03	66,000

NOTE: The apparent flash length in seconds is shown below the equivalent fixed intensity for each lamp-RPM combination. This beacon normally displays six flashes per rotation.

Colour factor for red and green lenses is 0.34.

TABLE A.3 (Cont'd)

EFFECTIVE INTENSITY OF LANTERNS
(Candelas)

3.8 FOR REFRACTOR TYPE ROTATING BEACONS:

(a) Crouse Hinds DCB-36, 120v, 1000W, CC-8, Tungsten Halogen Lamp
(b) Crouse Hinds DCB-10, 120v, 500W, CC-8, Tungsten Halogen Lamp

Beacon	(a)		(b)	
RPM	Effective Intensity	T	Effective Intensity	T
1	760,000	.28	44,700	.27
2	530,000	.23	31,600	.16
3	430,000	.16	24,800	.12
4	360,000	.12	20,500	.10
5	310,000	.10	17,600	.09
6	280,000	.09	15,500	.08
10	190,000	.06	10,600	.06
12	160,000	.05	9,100	.05
Fixed	1,700,000		95,000	

Note: T is the apparent flash length in seconds.
Color factors: RED 0.22, GREEN 0.20
Intensities listed assume the cover glass in place.

TABLE A.3 (Cont'd)

EFFECTIVE INTENSITY OF LANTERNS
(Candelas)

3.9 FOR LANTERNS: Stone-Chance "Seagull" 200 M/M Poly Carbonate
(Manufacturer's Figures - 2P/20)

VOLTS	AMPS OR WATTS	INTENSITY BY DURATION OF FLASH					
		FIXED	0.3 SEC.	0.5 SEC.	1.0 SEC.	1.5 SEC.	2.0 SEC.
12	0.55A	110	66	78	91	97	99
12	0.77A	160	96	114	133	140	144
12	1.15A	270	162	193	224	238	243
12	1.35A	350	-	250	290	308	315
12	2.05A	620	-	443	515	546	558
12	3.05A	900	-	643	748	792	810
12	48W	1100	-				
12	60W	1350	-				
6	0.25A	30	18	21	25	27	28
6	2.75W	65		46			
6	5.5W	130		93			

NOTES: 1. FOR FLASH LENGTHS GREATER THAN 2 SECONDS USE FIXED VALUE.

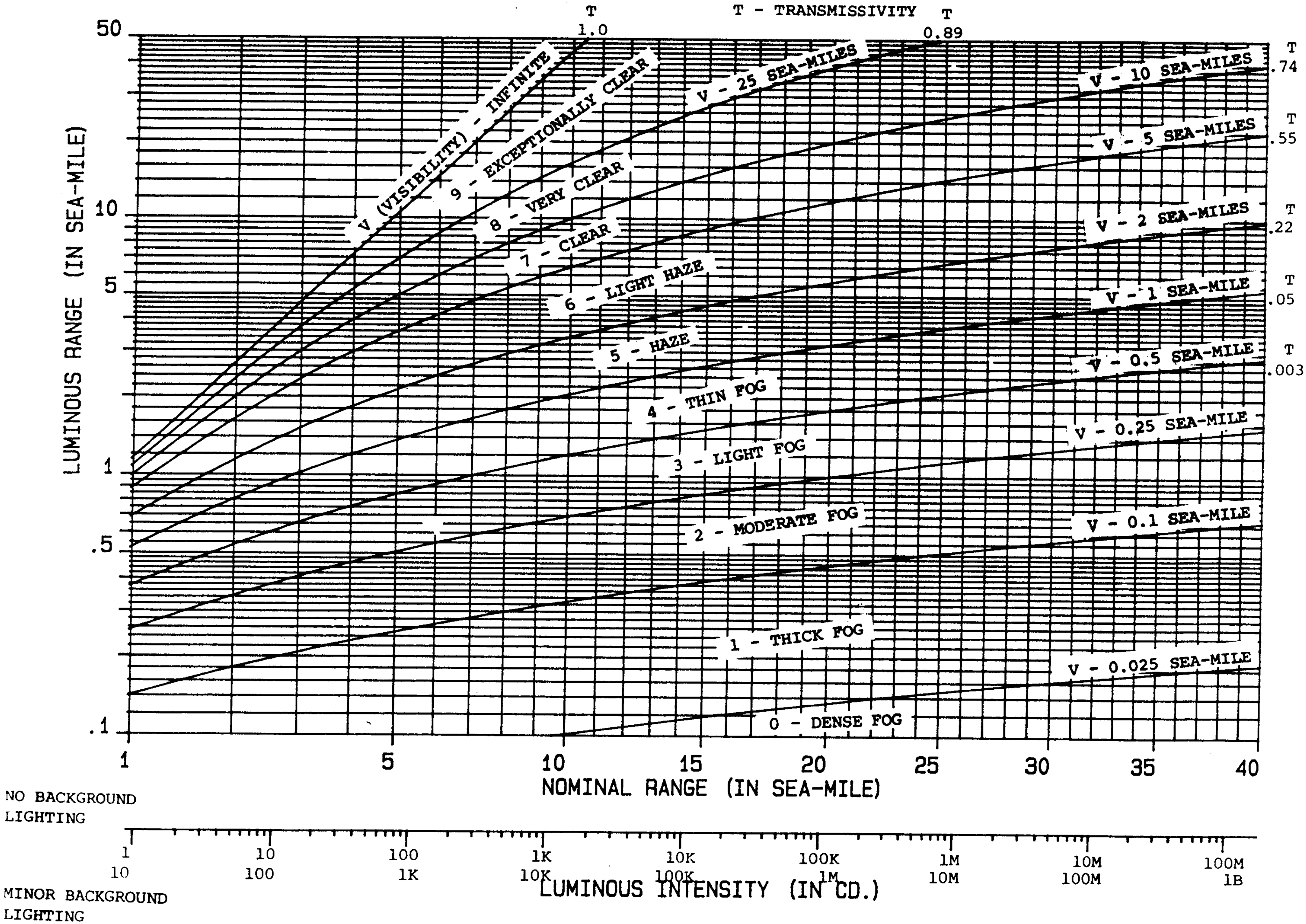
MULTIPLYING FACTOR FOR COLOURED LENS	
Red	0.24
Green	0.29
Yellow	0.73

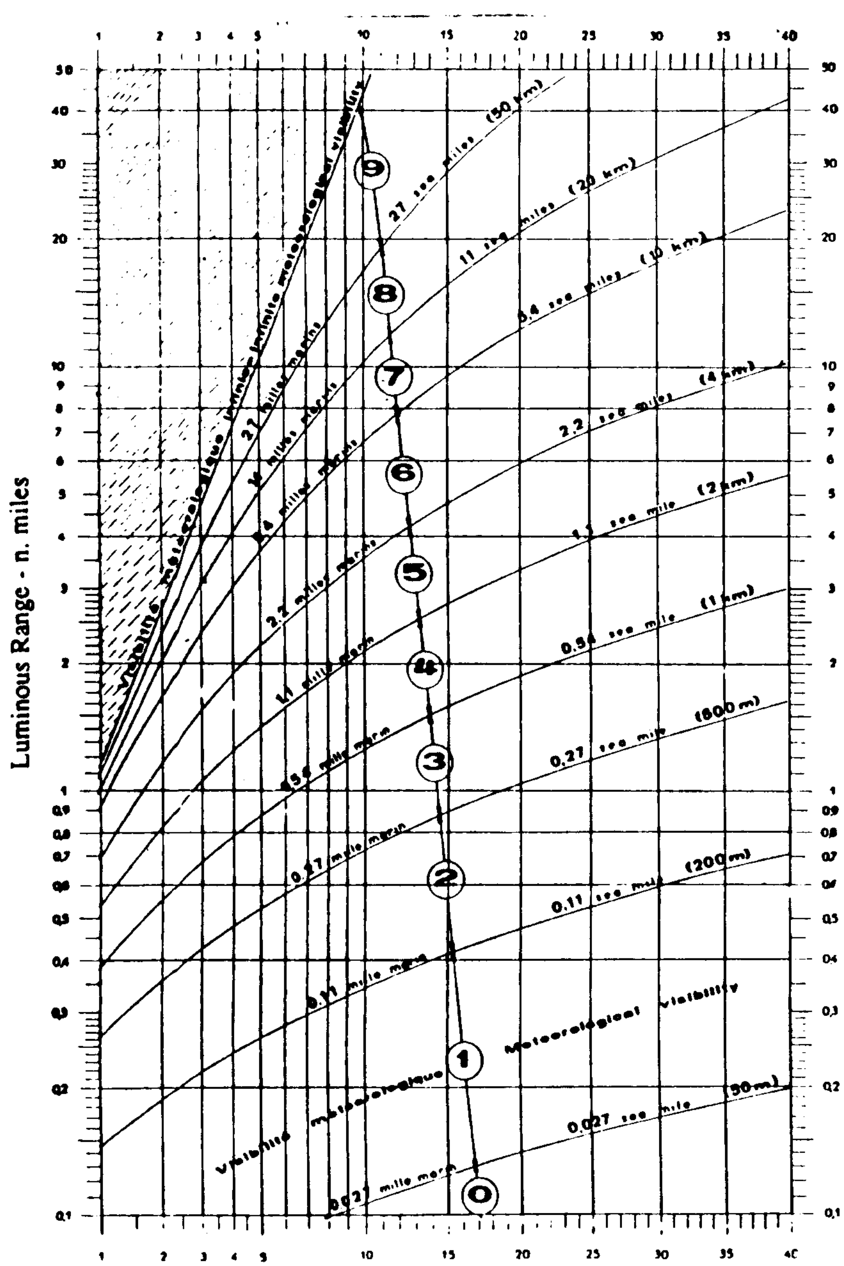
TABLE A.4

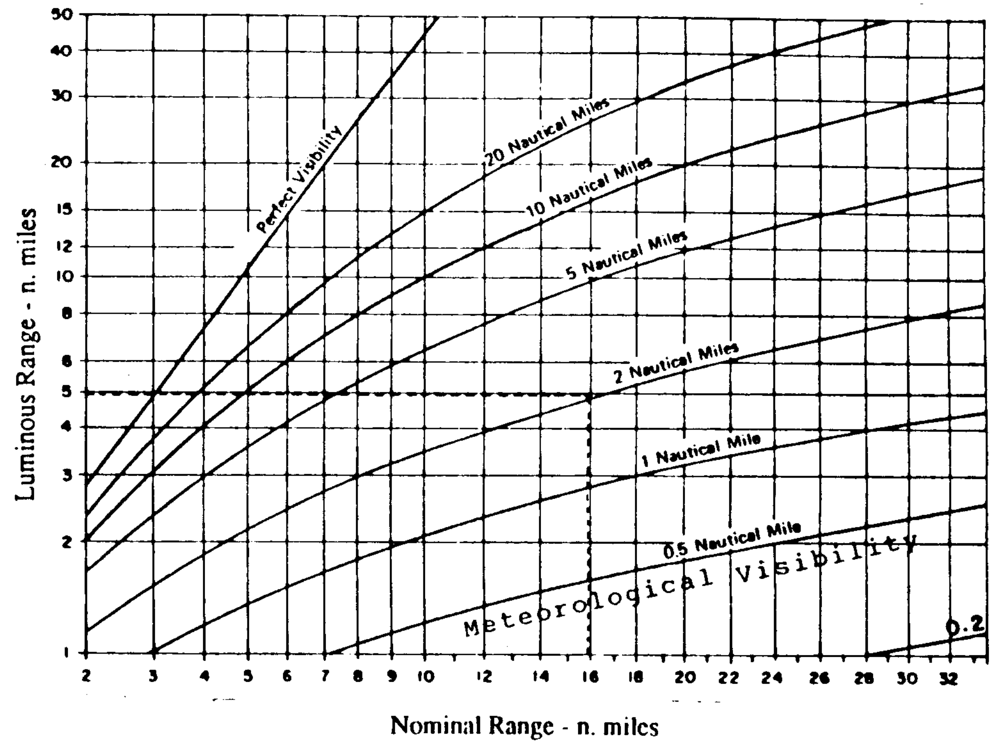
DETERMINATION OF NOMINAL RANGE FROM LUMINOUS INTENSITY
(rounded off to the nearest nautical mile)

Luminous intensity (more than)	*Nominal range (rounded off)*	*Luminous intensity (more than)*	*Nominal range (rounded off)*
candelas *(cd)*	*nautical miles*	candelas *(cd)*	*nautical miles*
1	1	433, 10^3	24
3	2	635, 10^3	25
9	3	927, 10^3	26
24	4	1,35 10^6	27
54	5	1,97 10^6	28
108	6	2,85 10^6	29
208	7	4,12 10^6	30
36	8	5,93 10^6	31
632	9	8,54 10^6	32
1,07 10^3	10	12,3 10^6	33
1,76 10^3	11	17,6 10^6	34
2,85 10^3	12	25,2 10^6	35
4,54 10^3	13	36,0 10^6	36
7,14 10^3	14	51,3 10^6	37
11,1 10^3	15	73,0 10^6	38
17,1 10^3	16	104, 10^6	39
26,2 10^3	17	148, 10^6	40
39,8 10^3	18	210, 10^6	41
60,0 10^3	19	297, 10^6	42
89,9 10^3	20	420, 10^6	43
134, 10^3	21	593, 10^6	44
199, 10^3	22	837, 10^6	45
294, 10^3	23	1180, 10^6	46

Example: If the luminous intensity of a light is 115 candelas (115 is greater than 108 and less than 208), the nominal range of this light is 6 nautical miles.


T - TRANSMISSIVITY
T 1.0
T 0.89
T .74
T .55
T .22
T .05
T .003
V (VISIBILITY) - INFINITE
9 - EXCEPTIONALLY CLEAR
8 - VERY CLEAR
7 - CLEAR
6 - LIGHT HAZE
5 - HAZE
4 - THIN FOG
3 - LIGHT FOG
2 - MODERATE FOG
1 - THICK FOG
0 - DENSE FOG
V - 25 SEA-MILES
V - 10 SEA-MILES
V - 5 SEA-MILES
V - 2 SEA-MILES
V - 1 SEA-MILE
V - 0.5 SEA-MILE
V - 0.25 SEA-MILE
V - 0.1 SEA-MILE
V - 0.025 SEA-MILE
LUMINOUS RANGE (IN SEA-MILE)
50
10
5
1
.5
.1
1
5
10
15
20
25
30
35
40
NOMINAL RANGE (IN SEA-MILE)
NO BACKGROUND LIGHTING
1 10 100 1K 10K 100K 1M 10M 100M
10 100 1K 10K 100K 1M 10M 100M 1B
MINOR BACKGROUND LIGHTING
LUMINOUS INTENSITY (IN CD.)





Example:

The nominal range of a light is 16 nautical miles. When the meteorological visibility is 2 n. miles, the luminous range of the light is now 5 n. miles.

Figure A•1
Conversion Chart for Nominal Range to Luminous Range Under Various Visibilities

TABLE A.5

GENERAL LIST OF FOG SIGNALS AND NOMINAL RANGE
(Including experimental units)

Type		Sound Pressure (Db @ 1 metre)	Frequency (Hz)	Nominal Range (n. miles)
Diaphones:	"F" Diaphone	155.5	180	2.70
	"B" Diaphone	144.5	122	0.75
	"C" Diaphone	142.5	-	-
AGA:	LIED 300 1 unit: 1kw	143	300	2.6
	2 unit: 2kw	146	300	3.5
	4 unit: 4kw	149	300	4.8
	FOG BELL: 25W	-	-	-
	40W	-	-	-
API:	SA 850/4A	133.6	840	2.0
	FA 390/1 or SA 850/1A*	-	-	0.5
	ELG 300 1 unit: 1kw	143	300	2.6
	2 unit: 2kw	146	300	3.5
	4 unit: 4kw	149	300	4.8
	*Mod Kit - simulated Bell			
Airchime:	KM 85	145.5	88	0.50
	KM 110	144.5	110	0.65
	KM 135	146.5	135	1.00
	KM 165	148.5	165	1.50
	EL-4 (400W)	142	500	1.7
Others:	Cunningham Air Whistle	127.5	-	
	Cunningham Air Horn	142.5	250	-
	Electric Powertone	142.5	450	1.30
	Fyr Fyter	136.5	500	1.90
	Leslie Supertyfon	145.5	250	1.30
	Leslie Supertyfon	133.5	-	1.70
	Warbler	-	-	-
	Stone Chance 200W	-	-	-
	400W	142.5	500	1.70
	800W	-	-	-
	Stone Chance 2KW	152.5	320	3.10
	Tideland - Buoy Horn	117.5	545	0.30
	Wallace & Tiernan FA242	137.5	400	1.25

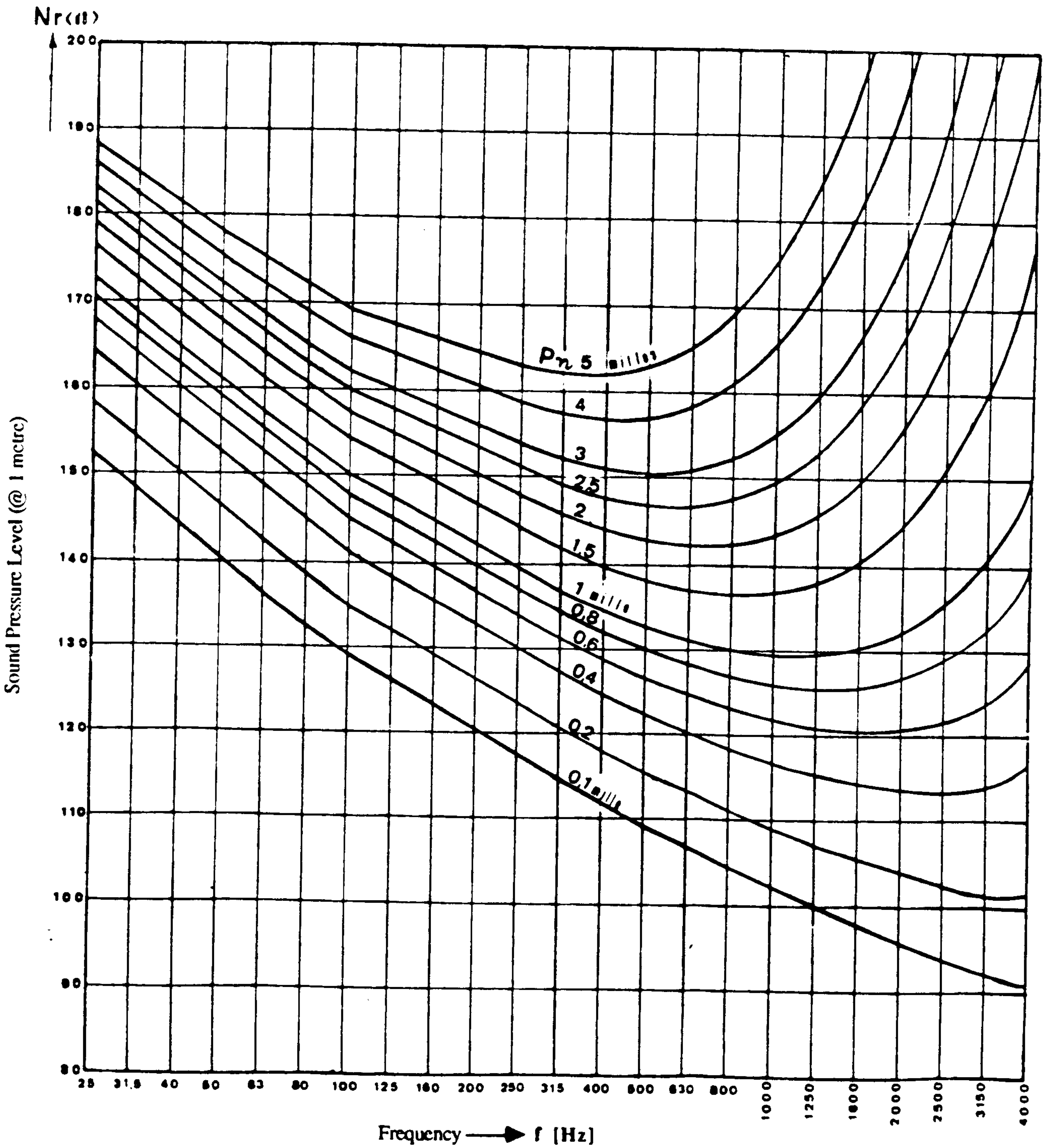
This list is to be used only to identify the nominal range capabilities of the various fog signals existing or proposed, to allow desk-top operational analysis of a site.

The list is not intended to convey the variations due to particular design or installation features such as directional, omni-directional coverage, height above water, etc.

Wherever a fog signal is being operated on reduced voltage to increase the reliability of the emitter, details are to be noted on the Site Inventory & Technical Data sheet and taken into consideration when analyzing the coverage of the signal.

Figure A•2
Determination of Nominal Range of Sound Signals

Nominal Range: The distance at which, in foggy weather, a lookout positioned on the wing of the bridge has a probability of 90% of hearing the signal when subjected to a noise which is equal to or in excess of that found on 85% of large merchant vessels, the propogation between the fog signal emitter and the listener occurring during relatively calm weather and with no intervening obstacles.



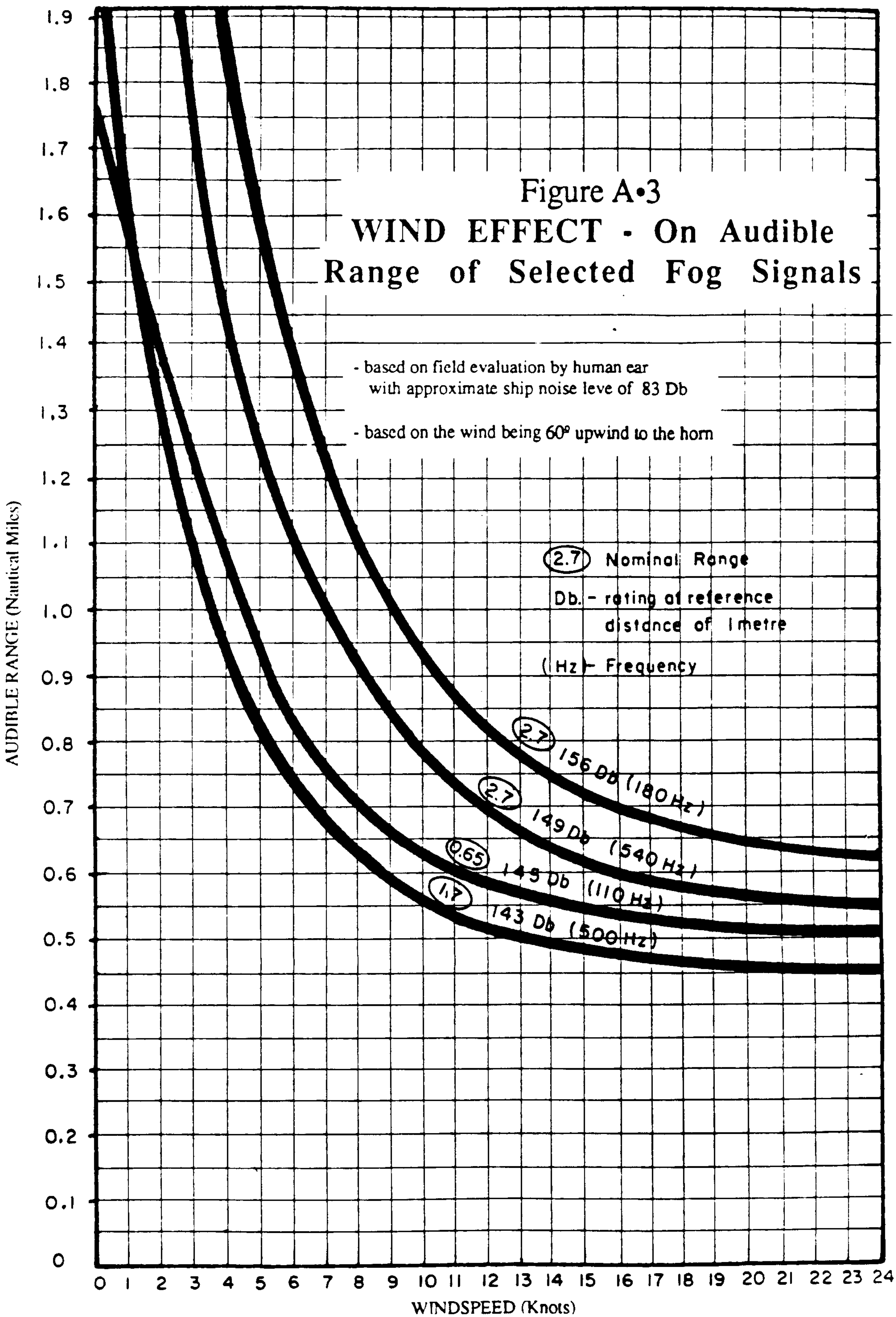


Figure A•3
WIND EFFECT - On Audible Range of Selected Fog Signals
- based on field evaluation by human ear with approximate ship noise leve of 83 Db
- based on the wind being 60º upwind to the horn
(2.7) Nominal Range
Db. - rating at reference distance of 1metre
(Hz) - Frequency
(2.7) 156 Db (180 Hz)
(2.7) 149 Db (540 Hz)
(0.65) 145 Db (110 Hz)
(1.7) 143 Db (500 Hz)
AUDIBLE RANGE (Nautical Miles)
WINDSPEED (Knots)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

TABLE A.6

BUOY LIGHT FLASH CHARACTERISTICS

Buoy Type (Function)	Light Colour	Primary Flash Characteristics (Cycle: flash\eclipse\flash\eclipse, etc.)	Secondary Flash Characteristics (Cycle: flash\eclipse\flash\eclipse, etc.)
Port	Green	Flashing (F1) 4S (.5/3.5)	Quick Flashing (Q) 1S (.3/ .7)
Starboard	Red	Flashing (F1) 4S (.5/3.5)	Quick Flashing (Q) 1S (.3/ .7)
Fairway	White	Morse Code A-Mo (A) 6S (.3 /.6/1.0/4.1)	Long Flash (LF1) 10S (2.0/8.0)
Bifurcation	Green or Red	Composite Group Flashing F1(2+1) 6S (.3 /.4/.3/1.2/.3/3.5)	Composite Group Flashing F1 (2+1) 10S (.5 /.7 /.5/ 2.1 /.5/5.7)
North Cardinal	White	Quick Flashing - (Q) 1S (.3/.7)	Very Quick Flashing (VQ) .5S (.2 /.3)
East Cardinal	White	Group Quick Flashing Q(3) 10S (.3/.7/.3/.7/.3/7.7)	Group Very Quick Flashing VQ (3) 5S (.2/.3/.2/ .3 /.2/3.8)
South Cardinal	White	Group Quick FlashingPlus Long Flash (Q (6) + LF1) 15S (.3/.7/.3/.7/.3/.7/.3/.7/.3/.7/.3/.7/2.0/7.0)	Group Very Quick Flashing plus Long Flash (VQ (6) + LF1) 10S (.2/.3 / .2/.3 /.2/.3 /.2/.3 /.2 /.3 /.2 /.3/2.0 /5.0)
West Cardinal	White	Group Quick Flashing Q(9) 15S (.3/.7/.3/.7/.3/.7/.3/.7/.3/.7/.3/.7/.3/.7/.3/.7 .3/6.7)	Group Very Quick Flashing VQ (9) 10S (.2/.3/.2/.3/.2/.3/.2/.3/.2/.3/.2/.3/.2/.3/.2/.3/.2/ 5.8)
Special Purpose excl. O.D.A.S.	Yellow	Flashing (F1) 4S (.5 /3.5)	
O.D.A.S. Scientific	Yellow	Group Flashing F1 (5) 20S (.5/1.5/.5/1.5/.5/1.5/.5/1.5/.5/11.5)	

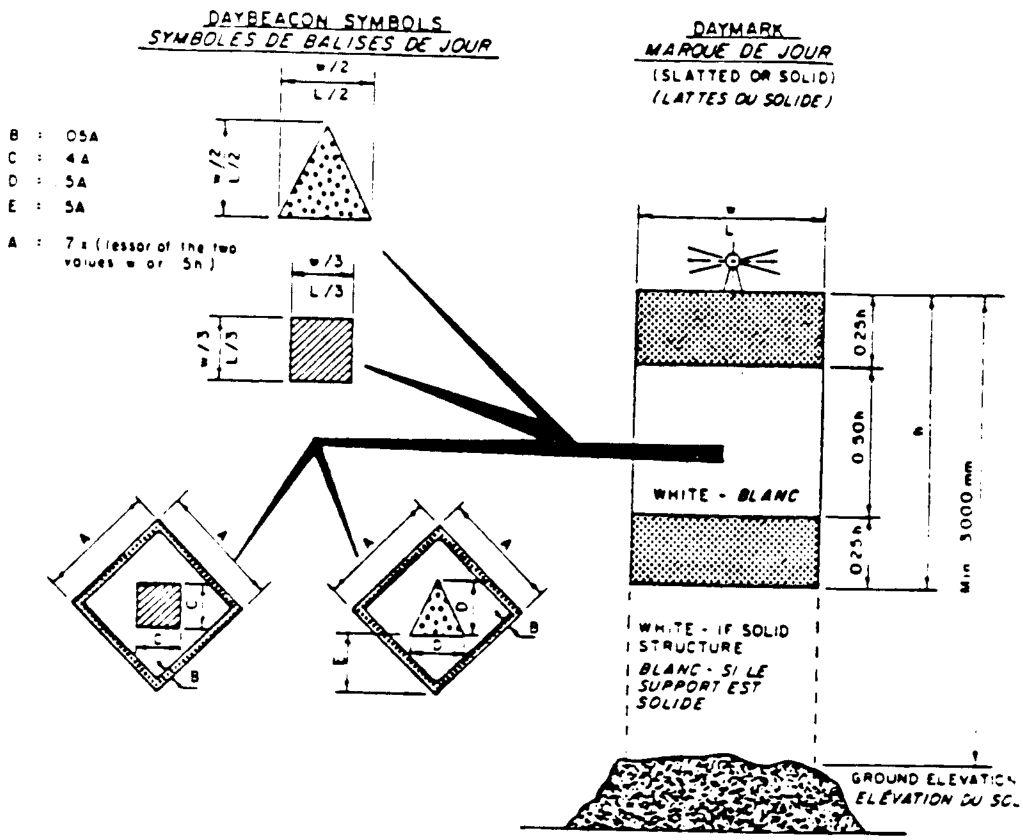
TABLE A.7

STANDARD DAYBEACONS - BALISES NORMALISÉES

SIZE SELECTION - CHOIX DE GRANDEUR

		DESIGN DISTANCE IN METRES DISTANCE VISIBLE EN MÈTRES		
SIZE IN MILLIMETRES GRANDEUR EN MILLIMÈTRES		1000	1500	3000
PORT BABORD	A B C	600 300 40	900 450 60	1800 900 160
STARBOARD TRIBORD	A B C D	800 400 30 80	1200 600 45 120	2400 1200 90 240
JUNCTION JONCTION	A B C D E		1200 60 450 600 600	1800 90 675 900 900
NUMBER-SIZES NUMÉRO-GRANDEUR	1 DIGIT CHIFFRE 2 DIGITS CHIFFRES 3 DIGITS CHIFFRES	100 100 80	150 150 100	400 250 150

Figure A•4
Daymarks for single lighted fixed aids
Marque de jour pour les aides fixes et lumineuses



SIZE SELECTION
SÉLECTION DE GRANDEUR

TABLE B

SITE ELEVATION ABOVE H W L / ÉLÉVATION DU SITE AU-DESSUS DU NIVEAU ÉLEVÉ DE L'EAU	MINIMUM PROJECTED SIZE OF DAYMARK (w x h) / GRANDEUR MINIMUM PROJETÉE DE LA MARQUE DE JOUR (Lxh)						BACKGROUND / ARRIÈRE PLAN
UP TO 3000 mm / JUSQU'À 3000 mm	900 mm x 1800 mm	900 mm x 2400 mm	900 mm x 3000 mm	1200 mm x 3000 mm	1200 mm x 4600 mm	1500 mm x 7300 mm	BROWN & GREEN / BRUN & VERT
ABOVE 3000 mm / AU-DESSUS DE 3000 mm	900 mm x 1800 mm	1200 mm x 1800 mm	1200 mm x 2400 mm	1200 mm x 3000 mm	1500 mm x 3700 mm	1800 mm x 6100 mm	
UP TO 3000 mm / JUSQU'À 3000 mm	900 mm x 2400 mm	900 mm x 3000 mm	1200 mm x 4600 mm	1500 mm x 7600 mm	1800 mm x 9800 mm	2400 mm x 11600 mm	GREEN or BROWN & WHITE or SKY / VERT ou BRUN & BLANC ou CIEL
ABOVE 3000 mm / AU-DESSUS DE 3000 mm	900 mm x 2400 mm	900 mm x 3000 mm	1500 mm x 3700 mm	1500 mm x 6100 mm	2400 mm x 7300 mm	3000 mm x 9100 mm	
DESIGN DISTANCE / DISTANCE VISIBLE	2700 m	3600 m	4500 m	5400 m	6300 m	7200 m	METRES

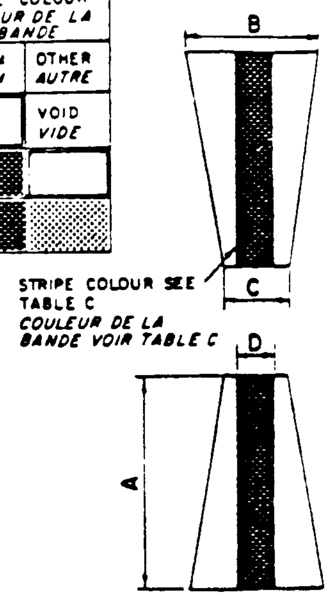
Figure A•5
Range daymarks
Marques de jour

COLOUR SELECTION
SELECTION DE COULEUR

TABLE C

BACKGROUND *ARRIERE - PLAN*	RECOMMENDED DAYMARK COLOUR *COULEUR DU FOND RECOMMANDÉES*	STRIPE COLOUR / *COULEUR DE LA BANDE* RECOM *RECOM*	STRIPE COLOUR / *COULEUR DE LA BANDE* OTHER *AUTRE*
SKY / SNOW - SUN BEHIND DAYMARK *CIEL / NEIGE - SOLEIL EN ARRIÈRE*			VOID *VIDE*
SKY / SNOW - SUN FACING DAYMARK *CIEL / NEIGE - SOLEIL EN FACE*			
VEGETATION, DARK BACKGROUND *VÉGETATION, ARRIÈRE - PLAN FONCÉ*			

REAR DAYMARK
MARQUE DE JOUR POSTÉRIEURE



FRONT DAYMARK
MARQUE DE JOUR ANTÉRIEURE

COLOUR CODES:
CODE DE COULEUR:

- BLACK / *NOIR*
- FLUORESCENT RED / *ROUGE FLUORESCENT*
- WHITE / *BLANC*

SIZE SELECTION
SELECTION DE GRANDEUR

TABLE D

SIZE IN MILLIMETRES / *GRANDEUR EN MILLIMETRES*									
	A	1800	2400	3000	3600	4200	4800	6000	7200
	B	1200	1600	2000	2400	2800	3200	4000	4800
	C	600	800	1000	1200	1400	1600	2000	2400
DESIGN DISTANCE IN METRES / *DISTANCE VISIBLE EN METRES*	D	300	400	500	600	700	800	1000	1200
1800									
2 700									
3 600									
4 500									
5 400									
6 300									
7 200									
8 100									
9 000									

TABLE A.8

NIGHT-TIME VISIBILITY RANGE OF REFLECTIVE MARKS AND BUOYS USING HAND-HELD AND BOAT-MOUNTED LIGHTS

LETTER SIZE	BUOY SIZE	BACKGROUND SIZE	BUOY DETECTION RANGE	COLOUR IDENTIFICATION RANGE	NUMBER READABLE RANGE
10	9'6"	12" X 39"	(a) 750 yd. (b) 1700 yd.	(a) 700 yd. (b) 1000 yd.	350 ft.
8	6'	21" X 24"	(a) 750 yd. (b) 1550 yd.	(a) 700 yd. (b) 1000 yd.	300 ft.
6	4'6"	18" X 21"	(a) 700 yd. (b) 1300 yd.	(a) 650 yd. (b) 900 yd.	250 ft.
6	2' can spar	8" X 32"	(a) 550 yd. (b) 1050 yd.	(a) 400 yd. (b) 800 yd.	250 ft.
4	O.R.T.	6" X 24"	(a) 500 yd. (b) 1000 yd.	(a) 400 yd. (b) 800 yd.	200 ft.

Notes:

(a) This measurement was made using a hand held light with a 3 Watt bulb and a 6 Volt battery (4,000 Candelas).

(b) This measurement was made using a boat mounted spotlight of 75,000 Candelas.

N.B. All measurements were made during good weather conditions with good visibility. Poor visibility conditions will reduce these measurements. All measurements were made using Level 1 backgrounds and figures. Use of Level 2 material will reduce all measurements.

Figure A•6
Standard Lighted Buoys

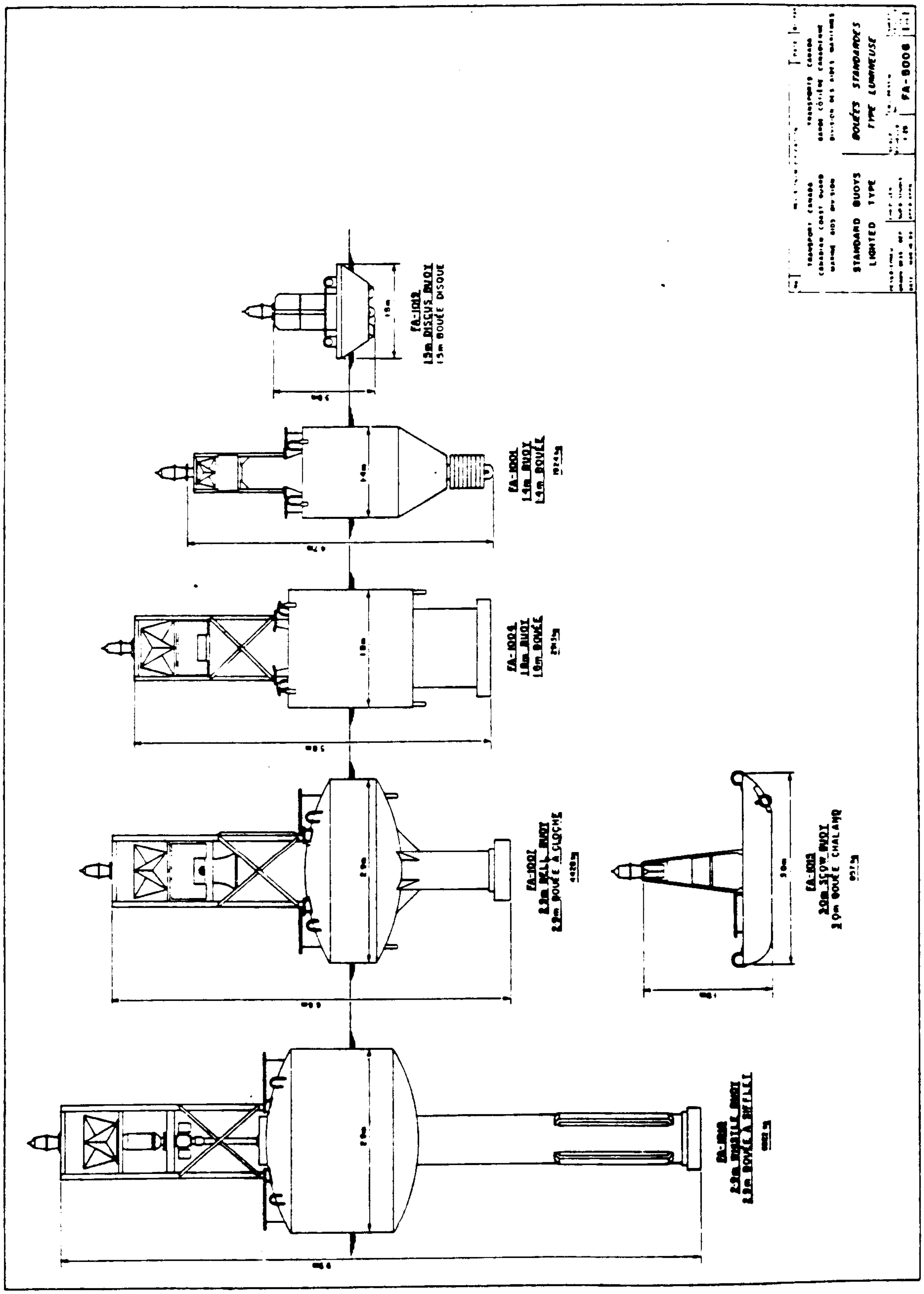


Figure A•7
CAN and CONICAL Buoys.

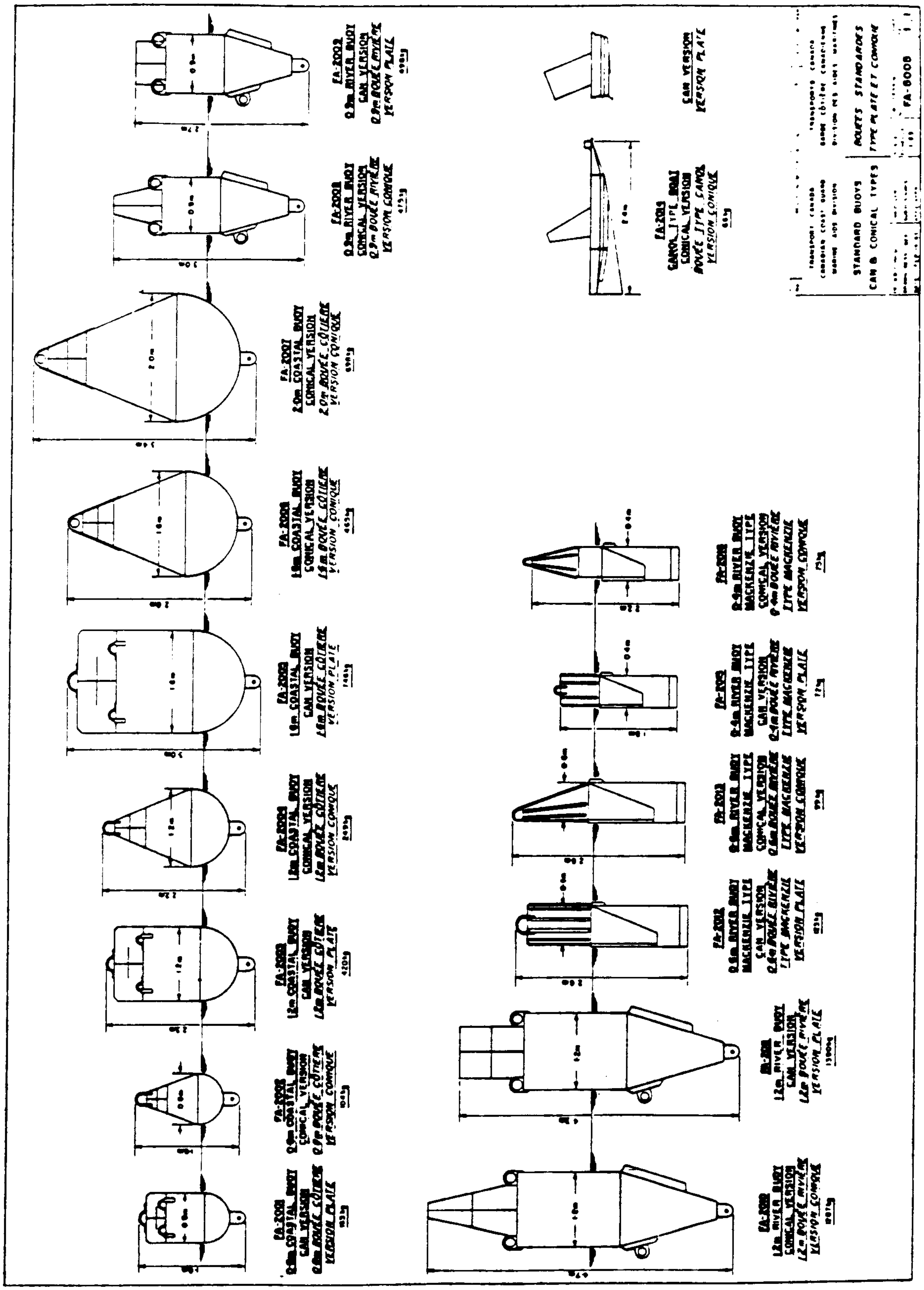
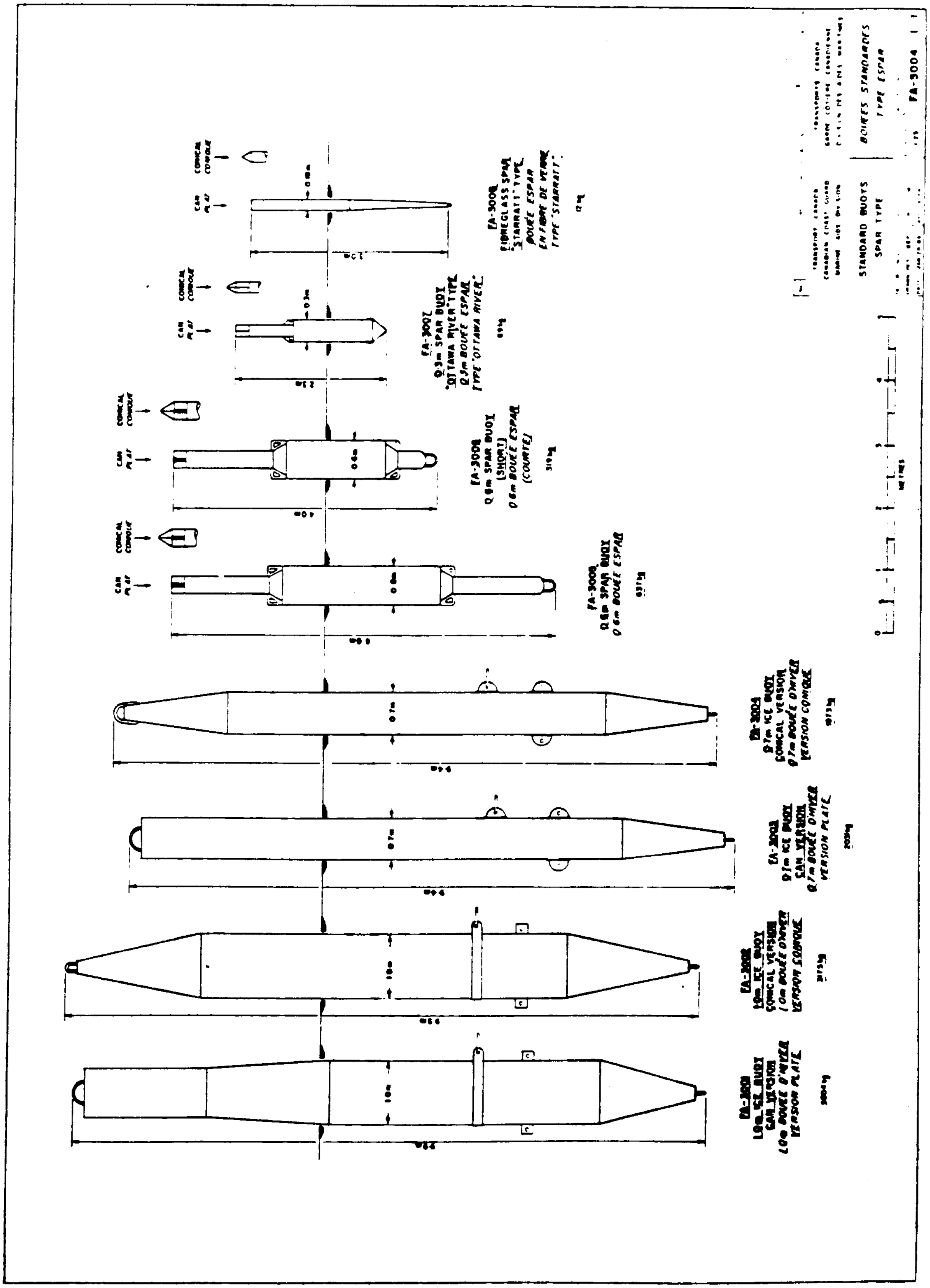


Figure A•8
Standard SPAR Buoys



APPENDIX B

GLOSSARY OF TERMS

Appendix B

Glossary of Terms

A.E.S.

Atmospheric Environment Service. Contact for weather information at:

Environment Canada
Atmospheric Environment Service
Canadian Climate Centre
Climatological Applications Br.
4905 Dufferin Street
Downsview, Ont.
M3H 5T4

Aid to Navigation

Any visual mark, aural or radio signal, external to a vessel, as described in the Canadian Aids to Navigation System booklet (TP968), that assists marine navigation.

Angle of Cut

The angle at which two lines of position intersect.

Angle of Turn

The angle subtended at the intersection of two consecutive required course lines.

Bell-Buoy

A large buoy carrying an acoustic device activated by wave motion, which causes hammers or suspended clappers to strike the sounding device or bell.

Boundary

The outer most limit of the navigable channel as determined by water depth, presence of hazards, bottom type, etc.,or as marked by aids to navigation boundary markers to confine or direct traffic.

Channel Width (Limits)

The distance, perpendicular to the preferred course line in a channel, between the channel boundaries on both sides.

Chart Datum

By International agreement, a plane below which the tide will seldom fall. The Canadian Hydrographic Service has adopted the plane of lowest normal tides as chart datum.

CHS

Canadian Hydrographic Service, Dept. of Fisheries & Oceans. Canadian Charting Authority.

CPA

(C)losest (P)oint of (A)pproach; that point on the course lines of two vessels at which one vessel will be in the closest proximity to the other.

Coastal Navigation

The directing of a vessel in navigable water by use of geographical (land-based) points and depths of water to determine relative position and ensure safe navigation.

Crabbing

The movement of a vessel such that there is an angular difference between the vessel heading and her actual track, caused by the lateral force of current, wind and/or waves.

Day Beacon

A fixed aid to navigation mark with lateral significance indicating direction to assist navigation.

Daymark

The daytime visual colour and shape characteristics of the structure supporting an aid to navigation light, or the mark affixed to said structure, or the daytime visible mark of a lit or unlit range.

Dead Reckoning

The estimation of vessel position by application of course and distance vectors.

Diaphone

A device producing a sound by means of a slotted piston moved back and forth by compressed air. Blasts may consist of two tones of different pitch, in which case the first part of the blast is high and the last part is low.

Design Availability

The minimum percentage of time during the worst month of the navigation season (i.e., the month when visibility is most frequently restricted) that, given local waterway weather patterns and conditions, operators of specific categories of vessels should be able to use (see, hear, etc.) an aids to navigation system, assuming the aids are functioning properly.

Deviation

- Compass - Divergence of a compass needle from magnetic north by magnetic disturbances originating from the vessel itself.
- Standard (Mathematical) - The average or standard error as determined by mathematical calculation having originated in random sampling and average errors.

Directional Symbol

A symbol of recognizable shape, colour and size added to a daymark or day beacon to give lateral significance.

Distinctive Mark (Signal)

A man-made or natural object of easily recognizable size, shape, colour, light or sound characteristics etc., in such a position that it may be identified on a chart or related to a known navigation instruction (List of Lights, Sailing Directions, etc.).

Estimated Position

An ascertained position computed by applying the effects of disturbing elements such as wind, current, imperfect steering, etc to a dead-reckoned position. Thus the estimated position is expected to be more accurate than the dead-reckoned position.

Fathom

Depth measurement; conversion equivalents - 6 feet, 1.83 meters.

Fixed Aid

An aid which is affixed to its position as distinct from floating aids; that is, an aid that is stationary while in use, although it may be moveable. Includes shore lights, day beacons, ranges, lights and markers on dolphins, piers, etc.

Fluctuating Water Level

This term describes changes in the water plane, above or below chart datum due to meteorological conditions, tide, current, man-induced change etc., in oceans, lakes, rivers, channels, river discharge areas etc., from the highest water level to lowest level reached during the navigation season.

Freezing Spray

Spray from precipitation or waves, etc. which freezes on contact with aids, vessels, etc and thereby impedes the functioning and visibility of aids as well as the functioning of vessel.

Gross Tonnage

The capacity measurement of a vessel, in units of 100 cubic feet or 2.83 m^3, including enclosed spaces within the hull and above the deck available for cargo, stores, passengers and crew, (certain spaces excepted).

Hazard

Any protruding or submerged obstruction (shoal, ledge, edge of dredged cut, wreck, or other fixed object) which has less clearance over it than the draught of the largest user plus a safety margin of "under-keel clearance" (see Threat Rating Guide) making allowances for swell, wave heights and fluctuating water depths.

Homing

In the context of this manual, homing is the process of heading directly toward an aid to navigation as a desired point of landfall, (e.g. steering on the main lightstation, fog signal or radio beacon). However, maintaining only a single navigational parameter is not regarded as prudent.

Horn (Diaphragm)

A device producing sound by means of a disc diaphragm vibrated by compressed air or electricity.

In Sight

An object is deemed to be in sight when it can be seen by eye from a vessel.

Instrument Approach

The process of making the approach to a landfall by use of navigation instruments, without dependence upon direct visual reference to land or aids to navigation.

Instrumental Error

Error due to inaccuracies in any part of a mechanism that provides navigation information including calibration errors and errors resulting from limitations of the instrument itself.

Knot

The unit of speed equivalent to one nautical mile per hour (6076.1 feet, 1852 meters).

Landfall

Landfall is the point at which the method of navigation changes from open water geographical coordinates, latitude and longitude, to coastal navigation using topographical reference marks (land, land-based aids, soundings, etc.).

Local Commercial Vessels(Category II)

Vessels being used for local commercial activities (such as fishing, tours) within an area where the operator has appropriate local knowledge, and equipped with a searchlight where night-time use of short-range marine aids is intended or may be necessary.

Long-Range Commercial Vessels (Category I)

Vessels operating with charts and sailing directions, equipped with radar, radio and radio positioning equipment in accordance with regulations, being used for long distance commercial purposes (such as carrying cargo or passengers, deep-sea fishing) and being operated by professionally trained and certified personnel (Class IV Fishing Master Certificate or higher).

Loran C

A long distance radio navigation system in which hyperbolic lines of position are generated by measuring two time differences of pulses transmitted in fixed time relationship from fixed - position transmitters. Generally useful to 1000-1500 nautical miles. Normal accuracy is between 100 and 500 feet.

Major Light

A shore light with a nominal range of 10 nautical miles or more, used primarily for landfall from open water (may include ranges when used in conjunction with other lights for primary landfall).

Major Fog Signal

A sound signal with a nominal range greater than 1 nautical mile, usually co-located with a major light.

Marker (Mark)

A man-made or natural object of easily recognizable size, shape or color, or a combination of same, situated in such a position that it may be identified on a chart or related to a known navigational instruction. An aid to navigation.

Minor Light

A light with a nominal range of less than 10 nautical miles.

Minor Fog Signal

A sound signal with a nominal range of 1 nautical mile or less, usually co-located with a minor light.

Most Probable Position

A position obtained by using all available position information (usually D.R. or E.P. and 2 lines of position).

Nautical Mile

One minute of latitude or one minute of arc of any great circle; equal to 6076.1 ft or 1852 metres.

Navigation Aid

Onboard instruments or equipment used to assist in navigation.

Navigational Need

The necessary navigation information indicators (or marks) required by the navigator to assist in maintaining a desired track within a specified waterway. Needs correspond to navigational threats identified at a site.

Nominal Range

The maximum distance, in nautical miles, at which a light may be seen in clear weather (International Visibility Code Standard).

P.P.I. - Plan Position Indicator (radar)

The screen (cathode ray tube) on which transceived radio waves from reflecting objects and transponded signals from racons are displayed in a map-like display.

Pilotage

The process of directing a vessel by visual, aural and/or radar observations of landmarks and other aids to navigation.

Pleasure Craft (Category III)

Vessels being operated for leisure activities by the owner or under charter, rent or loan and equipped with a search light where night-time use of short-range marine aids is intended or may be necessary.

Position Line

A line upon which a vessel lies, obtained by any method (e.g. transit, hyperbolic, (Loran C, Decca, SatNav), bearing (Compass), range (radar), angular difference (sextant), etc.).

Racon

A radar "beacon" or transponder used to reply to interrogations from radars. The response produces a morse code pattern on a radar PPI in the form of a radial line extending from the position of the RACON to the far side of the PPI, thereby allowing the manner to identify and obtain a bearing of the beacon.

Radar

A radio detecting and ranging system that indicates the presence of objects and their range (distance) by the transmission and return of electromagnetic energy; direction is obtainable through use of a rotating directive antenna.

Radar Reflector

A device of reflective surfaces, mutually intersecting at right angles, designed to return electro-magnetic radiations toward their source and used to improve target resolution for radar observations.

Radial Error

Vessel fixing error, which varies directly with the method used to determine position.

Radio Beacon

A non-directional radio facility emitting identifiable signals intended for radio direction finding observations.

Registered (Net) Tonnage

A capacity measurement reached by deducting spaces used for accommodation of a vessels crew, navigation equipment, propulsion machinery and fuel storage from a vessel's gross tonnage.

Secondary Landfall

Landfalls occurring during coastal, or point-to-point navigation phases of a voyage after traveling from a confirmed position out of sight of land or land-based marks for a limited period of time.

Siltation

The accumulation of silt, sand, rock or debris to such an extent that after time a navigable body of water or channel is affected detrimentally or changed and necessitates an alteration to the pilotage of that area.

Siren

A device producing a sound by means of either a disc or cup-shaped rotor actuated by compressed air, steam or electricity.

System of Aids

A single aid or group of aids covering a designated site and intended to (collectively) provide sufficient and timely information with which to safely navigate vessels within and through that site.

Target (radar)

An object of radar search; or any discrete object which reflects electromagnetic discrete energy back to a radar.

Threats

Those environmental conditions and physical features of a waterway which adversly affect the control and navigation of vessels and which, without extra caution on the part of mariners and/or assistance from aids to navigation, could result in vessel damage and injuries to mariners.

Wave Height

Wave heights are the combination of wind-wave and swell heights, measured vertically from crest to trough.

Whistles

A device that produces a sound by emitting compressed air through a circumferential slot into a cylindrical bell chamber. May be buoy-mounted or shore-based, and be powered by wave action or electrically.

APPENDIX C

LANDFALL DESIGN

APPENDIX C: LANDFALL DESIGN

(PERCEPTION REQUIREMENT AND GATE DESIGN FOR SHORT-RANGE AIDS TO NAVIGATION)

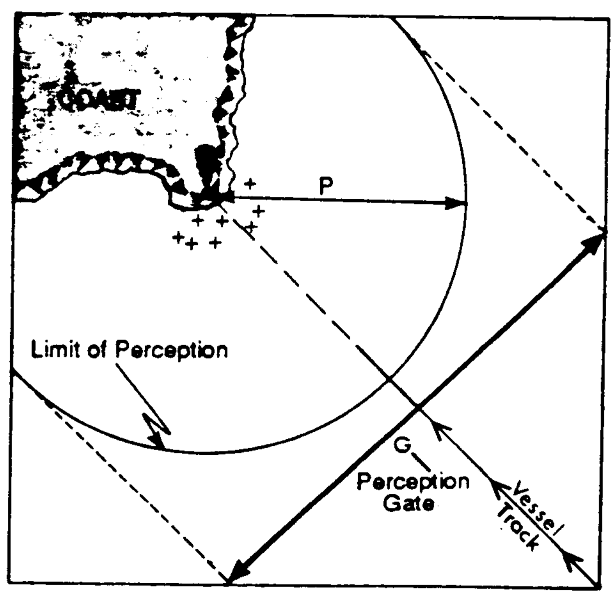
C.1 Introduction

Perception Requirement (P) is defined as the minimum distance at which a visual aid must be seen, an aural aid heard or a transmitted or reflected radar signal received. It is expressed as P, the radius of a circle whose centre is at the aid itself. (Diagram 1).

The Perception Gate (G) is a linear width, measured perpendicular to a line between an aid to navigation and an approaching vessel, that outlines the perception limits of that aid (Diagram 1).

The purpose of this appendix is to outline the method to be used to provide an ample perception gate, with local vessel traffic requirements, safety and equipment efficiency in mind. Generally this Perception Gate can be expressed as 2P. (The exceptions, discussed in Section C.6.4 and C.6.5, are when a parallel or oblique approach is being made to a land-based aid.)

Diagram 1: Perception Requirement (P) and Gate (G)



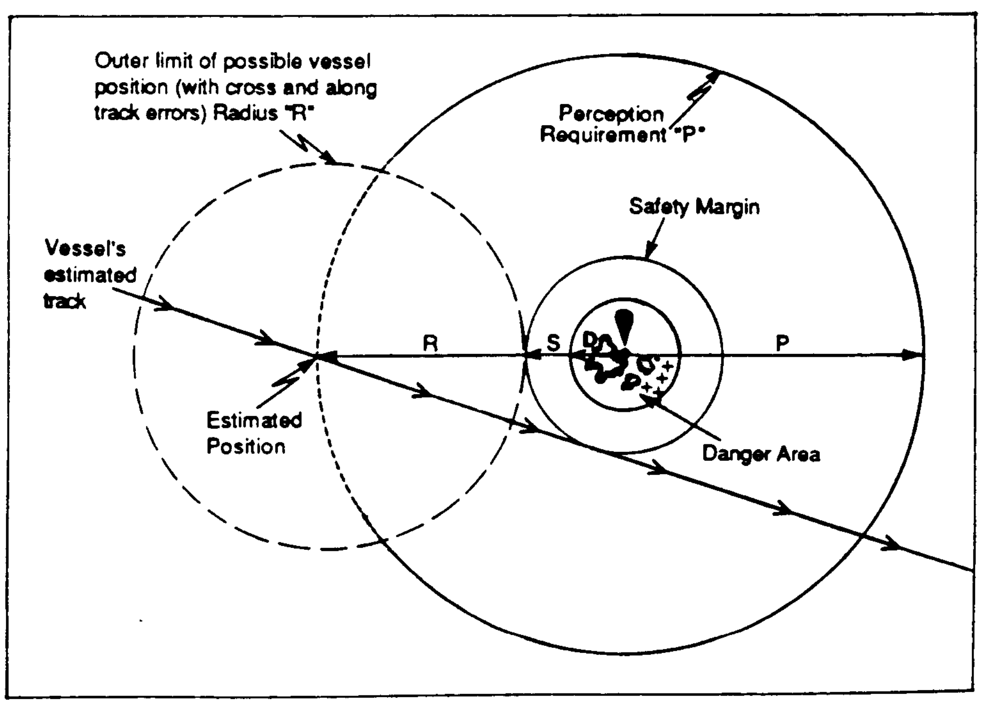
The Perception Requirement (P) calculation is essential to the design and review of open water, coastal and confined water aids to navigation systems. P accounts for three factors that must be provided for to support navigational safety: site danger area, vessel position inaccuracy and a safety margin. The sum of these allow a mariner to determine proper function of the aid, confirm the vessel's position and, if necessary make an evasive manoeuvre. The distance (radius) P is used as the absolute minimum geographic and nominal range that will allow an adequate perception gate (see diagram below) for that navigational aid or aids system. An aid not perceived in time invites disaster.

In some cases an aid will be used significantly more by one of the three vessel categories. P, however, must be calculated for each user category. The largest P value is then used in design of the aid or aids system to be fitted at that site. Or, when reviewing a site, the largest value of P is the minimum acceptable range of coverage for that aid or system.

C.2 Calculating P Perception Requirement (P)

The perception requirement is the sum of three radii, or factors, Danger Area (D), Safety Margin (S) and Radial Error (R), as shown below in Diagram 2. These factors and the methods of calculating them are given in the sections which follow.

Diagram 2: Perception Requirement D, S, and R (P=R+S+D)



C.3 Danger Area (D)

A fixed aid to navigation is often surrounded by a "danger area" characterized by unmarked shoals or outlying rocks that may or may not be marked by lesser aids. Lesser aids such as lighted buoys that lie between the desired track or approach (within the perception area) and the hazard may be used to reduce the danger area around a major light or aid. Thus the danger area, radius D, is the distance:

(a) for existing aids to navigation systems under review

- from the position of the aid marking a landfall to the outermost relevant (see Chapter 5) unmarked hazard lying between the aid and a specified or desired track or approach; or

(b) for aids to navigation systems under design:

- from the potential or most advantageous position for the landfall aid to the outermost relevant unmarked hazard lying between the aid and the specified or desired track.

D can be reduced or eliminated by the establishment of other aids, to mark the outermost relevant hazard between the aid and any specified or desired track or approach (provided, of course, that such aids meet the required Design Availability). Note that in the situation where the aid is located in a fairway, and is not marking a hazard, (e.g. fairway, vessel traffic system or special purpose buoys) there is no "danger area" and the value of D is zero.

C.4 Safety Margins (S)

Safety margins, or in mariner's terminology "minimum distances off" are variable distances that are determined by vessel masters and operators to allow for the vessel's size, manoeuvrability, speed, operational standards, meteorological and sea conditions, the area being transitted, etc..

The safety margin for navigational aids, though based on the same factors, must be provided to allow time for the navigator to react when an aid does not become available (visible, audible, etc.) at the estimated, or dead-reckoned time. It must be sufficiently beyond the danger area to allow the mariner time to realize that an aid may not be functioning (e.g. that the light is extinguished or that a floating aid has moved from its charted position.

The value of S is determined by the size and type of vessels navigating through or within the site in which the aid is located. For each category of user this must be based on the vessel which requires the longest reaction time and distance to complete an evasive manoeuvre. As detailed above, the numerous factors involved in determining the minimum safety distance complicate this choice.

To simplify this process, safety margins have been predetermined for each type of vessel (corresponding to the vessel types provided on the Threat Rating Guide) by a group of senior Coast Guard Masters and confirmed by representatives of each type of user.

These figures are presented on Chart C.1.

If, for example a 150' General Cargo Vessel is the largest and least capable user at site (regarding manoeuvrability and stopping capability), the safety margin (S) = 1 nautical mile.

C.5 Radial (Vessel Position) Error (R)

No position or "fix" taken for navigation purposes is 100% accurate. Depending on the area navigated, the acceptable error varies from several nautical miles for open ocean navigation to a few meters for inland passages. For that reason, the prudent navigator will use the most appropriate fixing method available at the time, taking into account accuracy, speed and convenience, in addition to using some means of dead-reckoning (estimating) to confirm the position. The calculation of perception requirement, P, must allow for position or radial error. This factor, Radial Error (R), varies considerably by type of vessel, equipment on board and used, and the areas and distances transitted.

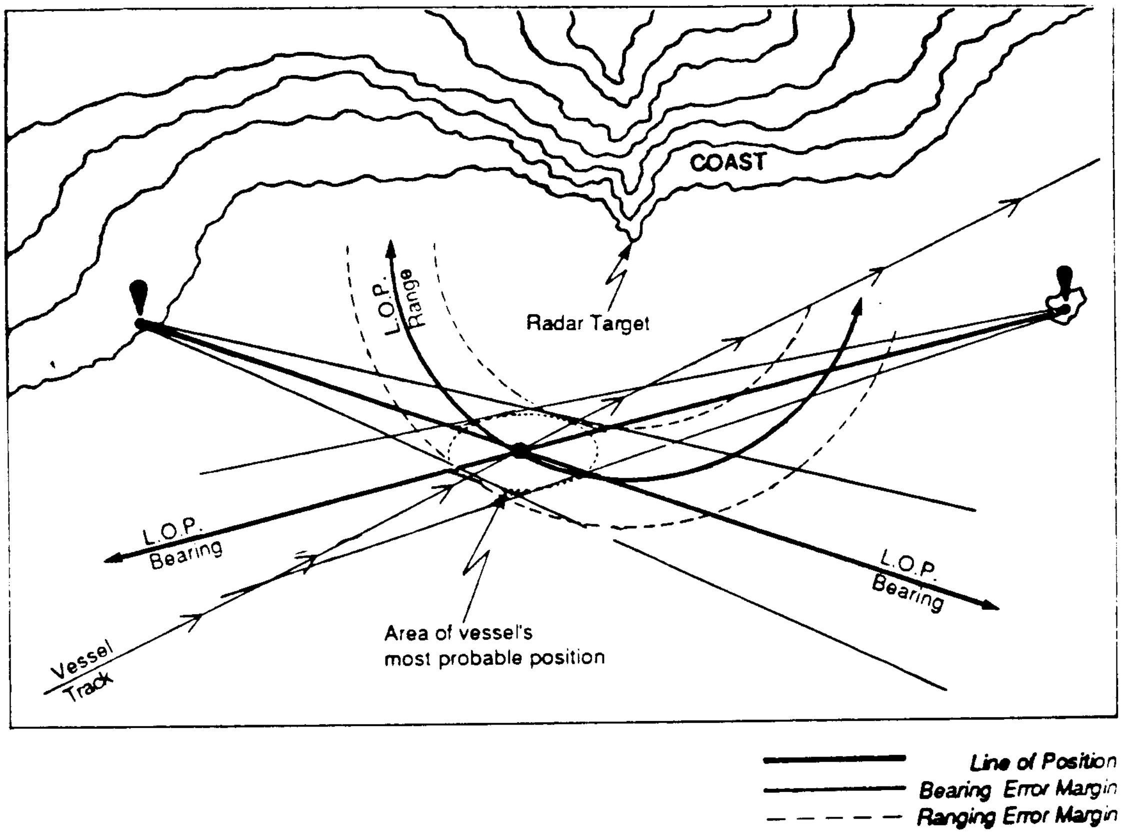
Fixes are generally calculated by obtaining several lines of position, such as bearing, range, hyperbolic, latitude and longitude, etc. These lines of position are only as accurate as the instrument used to obtain them and the operator of that instrument. Errors in position fixing are the result of position line inaccuracies, as they are observed, plotted, or as a result of instrumental error. Lines of position are regarded, therefore, as having a certain width caused by these errors which varies directly with the type of instrument used. This width can be described as an angular or linear measurement. The intersection of two or more lines of position forms an area, the shape of an ellipse or circle, containing error common to all lines. This area is known as the area of most probable position. (Diagram 3).

CHART C.1

NECESSARY SAFETY MARGINS, BY TYPE OF VESSEL

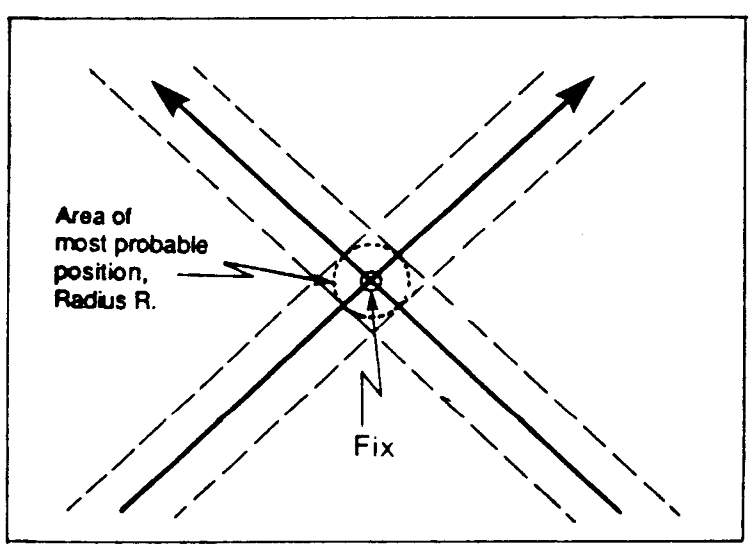
SIZE AND TYPE OF VESSELS					
Length (feet)	**Gross Tonnage**	**Beam (feet)**	**Draught (feet)**	**General Types**	**Safety Margin N-Miles**
1000-	80,000 - 140,000	140' - 200'	54' - 80'	Ocean-going tanker, ore and bulk carrier	2.0
1000+	32,000 - 37,000	105'	26' - 40'	Laker, bulk freighter and self unloader (American)	2.0
800 - 1000	30,000 - 100,000	95' - 175'	26' - 64'	Ocean-going tanker, ore and bulk carrier	2.0
730 - 1000	12,000 - 28,000	70' - 105'	26' - 40'	Laker, bulk freighter and self unloader	2.0
630 - 800	10,000 - 60,000	60' - 140'	20' - 54'	Tanker, ore and bulk carrier, general cargo	1.5
700 - 730	11,000 - 25,000	62' - 78'	21' - 35'	Laker, bulk freighter and self unloader	1.0
550 - 630	8,000 - 30,000	55' - 105'	20' - 42'	Tanker, ore and bulk carrier, general cargo	1.0
300 - 550	2,500 - 20,000	43' - 105'	16' - 38'	Tanker, ore and bulk carrier, general cargo	1.0
300 - 600	2,500 - 13,000	56' - 90'	13' - 20'	Car ferry	1.5
200 - 300	10 - 1,500	12' - 70'	2' - 9'	Car ferry	1.0
200 - 300	2,000 - 3,500	23' - 65'	9' - 20'	Tanker, bulk freighter, self unloader, fish factory	1.0
200 - 250	2,000 - 3,000	40' - 60'	8' - 20'	Small tanker, general cargo, fishing	1.0
150 - 200	1,500 - 2,500	30' - 50'	6' - 15'	Small tanker, general cargo, fishing	1.0
90 - 150	200 - 800	12' - 50'	4' - 15'	Small tanker, general cargo, fishing	1.0
65 - 100	40 - 250	13' - 28'	5' - 15'	Tugs, small draggers, long liners, pleasure craft	1.0
45 - 65	20 - 160	9' - 16'	4' - 15'	Tugs, work boats, small draggers, inshore long Liners, pleasure craft	1.0
32 - 45	8 - 50	4' - 14'	3' - 9'	Tugs, work boats, fishing (Cape Islanders, trollers), pleasure craft	1.0
25 - 35	4 - 20	4' - 11'	3' - 5'	Tugs, work boats, fishing trollers, pleasure craft	0.5
12 - 25	1 - 7	3' - 8'	2' - 4'	Tugs, work boats, inshore fishing, pleasure craft	0.5
300	10 - 1,000	12' - 80'	2' - 5'	Athabaska River tugs and barges	0.5
up to 950	10,000	160'	6'	Mackenzie River tugs and barges - upstream	0.5
up to 950	10,000	160'	6'	Mackenzie River tugs and barges - downstream	1.0

Diagram 3: Area of Most Probable Position



The area of most probable position is portrayed, by convention, as a circle, radius R, which varies in size with the accuracy of the fixing method used (see Diagram 4). Using accuracy limits as stipulated by the International Maritime Organization (IMO) and the following calculations for R, the circle described will encompass a vessel's actual position 95% of the time.

Diagram 4: Radial Error



Landfall

Technological advances improve shipboard long and short-range navigational aids systems continually. Due to these advances, the uncertainties of traditional landfall (the transition from open-water geographical coordinates: latitude and longitude calculated from astrological observations, to coastal topographical references: i.e. land, land-based marks or aids, measurable soundings, etc.) have largely become a thing of the past.

Radio, hyperbolic and microwave navigation systems have become widely accepted and "instrument approaches" accepted as the normal means of landfall and coastal navigation. Increasingly, these devices are being used to provide greater navigational accuracy and are being fitted aboard even the smaller vessels. Navigators are required to be proficient in their use. Their use affects the design of short-range aids systems in ways that can reduce costs.

In keeping with the advance of technological and navigational equipment standards, the methods of design for conventional aids to navigation systems must reflect these improvements. It is assumed that within reason, electronic aids such a depth-sounders and radar are fitted, operational, accurate and proficiently used by trained and certified personnel (Refer to Aids and Waterways Operational Manual TP1526, Directive 2-2200 "Design of Short-Range Aids to Navigation Systems").

For the purpose of this manual, three calculations of Radial Error have been adopted:

A. Instrument Approach (Radar) Radial Error - Used for Category 1, Long-range Commercial Vessels approaching a landfall who steer by compliance compass and fix from radar observations of land or land-based marks and on-board electronic navigation aids. By compliance compass we mean any compass that complies with the standards for Navigating Appliances and Equipment Regulations TP 3668.

B. Non-Standard Compass/D.R. Radial Error - Used for categories II, Local Commercial and III, Pleasure Craft. - those users who steer by non-standard compass and fix from visual observations of land or land-based marks.

C. Compliance Compass/D.R. Radial Error - Used for Category I Long-Range Commercial vessels making secondary landfall or in poor visibility, steering by compliance compass and using available on-board navigational aids for positioning (radar).

In addition, it must be stated: marine aids to navigation are not intended to, at any time, compensate for the failure or unreliability of on-board navigational equipment or watchkeeping.

A. Instrument Approach (Radar) Radial Error

A long-range commercial vessel's navigational transition from an instrumental approach by long-range aids such as Loran-C, Sat-Nav, etc., to coastal navigation is made initially by a landfall. This primary landfall is characterized by the appearance of land or land-based aids on their radar screen (PPI). Observation of one point of land that is distinctly identifiable enables a fix by range and bearing, confirming the vessel's dead reckoned or electronically calculated position.

Navigation will continue in this manner and, as the vessel nears land, the radar position continually increases in accuracy. As a result of radar navigation, the requirements of Category 1 vessels for short-range landfall aids to navigation, such as very large landfall lights, has been reduced or eliminated. There is no longer an abrupt change from open water navigation to pilotage, or a need for vessels to see land visually to carry out coastal navigation. Indeed, it is very common for coastal vessels to travel long distances out of sight of land and short-range aids to navigation. When doing so, they depend on radar for accurate fixes, using long range hyperbolic systems when outside of radar range and then, when nearing land, resuming navigation by radar.

Conventional short-range aids systems, however, are still a vital part of coastal navigation. For Category 1 vessels the need for conventional aids is reduced where distinctive natural radar targets or other appropriate radar aids are provided (e.g. Racon) to such an extent that a confirmed landfall is possible. When, by needs analysis, it has been deemed necessary to calculate visual coverage requirements and only Category 1 vessels are making landfall at a site, the following method of calculation for Radial Error, R, can be used.

A radar's ability to supply accurate bearing lines of position is affected by instrumental rounding off, alignment and compass errors. Resolution difficulties caused by yawing on a stabilized display widens all echoes, making bearing lines even less accurate. Errors in radar bearings can total more than 4 degrees.

Certified mariners (required on Category 1 vessels) know that the exclusive use of radar bearings for position fixing should be avoided. Radar ranges are consistent and easily checked (variable range marker against fixed range rings on the radar PPI) for accuracy and are recommended for use instead.

Assured of the identifiability of an aid or landmark, a navigator can take advantage of the radar's most accurate function, distance information. Regulations specify the maximum standard deviation for an obtained range to be $1\frac{1}{2}\%$ of the distance between the vessel and the target/mark, or 70 meters (0.037 nautical miles), whichever is the greater.

For example: The maximum allowed inaccuracy of a range taken on a radar scale of 24 miles is 0.36 nautical miles;
of 12 miles is 0.18 nautical miles; and
of 6 miles is 0.09 nautical miles; etc..

Combining Errors

Combinations of several errors are inherent to navigation. The means of combining the errors (or deviations) is to take the square root of the sum of the squares of the individual deviations: or, in other words, the root mean square.

$$\sigma \text{ combined} = \sqrt{\sigma_1^2 + \sigma_2^2 + \sigma_3^2}$$

where σ = deviation

For example:

1. A fix obtained from 2 radar ranges of objects at distances of 5 nautical miles each from the observer. Radar scale set at 12 miles.

   $\sigma_1 = (5 \text{ n.m x } 1\frac{1}{2}\%)$ $\quad$ $\sigma_2 = (5 \text{ n.m x } 1\frac{1}{2}\%)$

   $$R = \sqrt{(5 \times 0.015)^2 + (5 \times 0.015)^2}$$

   $= 0.106$ or 0.11 nautical miles.

2. A fix obtained from 1 radar range at a distance of 14.5 n.m. from the observer (radar scale set at 24 n.m.) and a bearing.

   The actual numerical bearing figure (i.e. 015° true) is inconsequential. The error does not change. Assume a bearing error of 5 degrees to include all possible inaccuracies, for all bearing error calculations.

Range error: σ_1 = 14.5 n.m. x 1.5%
= 0.2175 n.m. or 0.22 nautical miles

Since .22' is greater than 0.037' (70 meters), use .22 n.m. as the range error for this example.

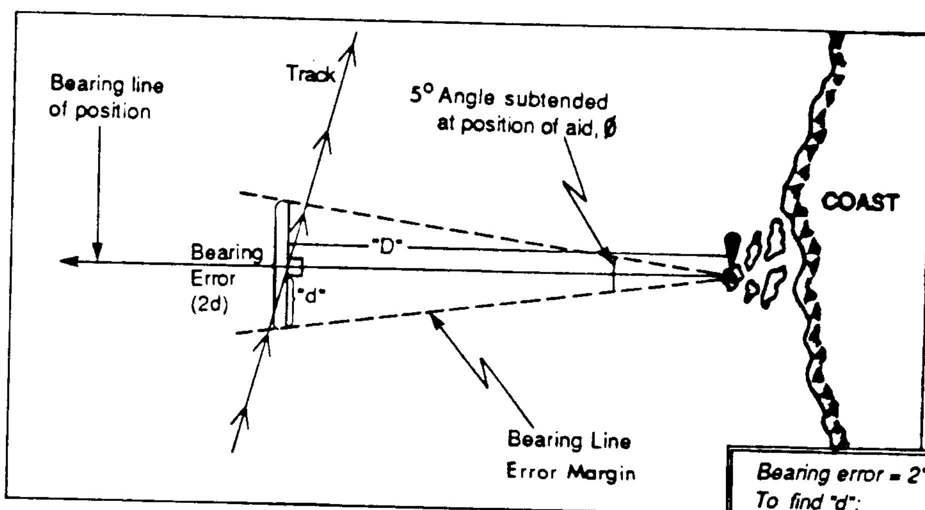
Bearing error: $\sigma_2 = 5°$ (error) or $\phi = 5°$
target 14.5 n.m. from the observer.
Refer to Bearing Error diagram below.

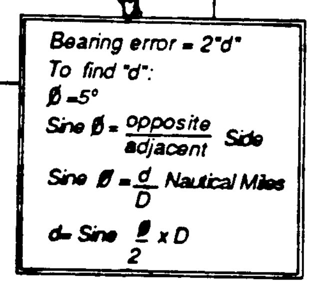
ϕ = 5°
D = 14.5 n.m.
d = sine ($\frac{1}{2}\phi$) x adjacent side (D)
d = sine ($\frac{1}{2}$ x 5°) x 14.5
d = sine $2\frac{1}{2}$ x 14.5
d = 0.04362 x 14.5
d = 0.63 n.m.

Since the bearing angle was (ϕ) by two at the beginning of the calculation to make a right angle triangle:

Bearing error = 0.63 n.m. x 2
= 1.26 n.m.

Diagram 5: Bearing Error Calculation





Combining errors: Range error - σ_1 = 0.22 n.m.
Bearing error - σ_2 = 1.26 n.m.

$$R = \sqrt{\sigma_1^2 + \sigma_2^2}$$

$$= \sqrt{0.22^2 + 1.26^2}$$

$$= \sqrt{0.0484 + 1.59}$$

= 1.28 nautical miles.

Point-to-Point Navigation

Once a landfall has been made from open water, the vessel's navigational mode may change to coastal, or point-to-point navigation. A vessel that prefers to maintain its courses or whose passage requires crossing in open water, will require a secondary landfall. Coastal vessels often plan passages that require such periods outside of visual range of natural landmarks or of visual aids to navigation. Poor visibility conditions may create periods in which visual aids are not available. In these situations a prudent mariner's course will be a compromise between the shortest route and the route leading from mark to mark, steering by compass and dead reckoning (estimating) the vessel's position. A vessel will use available electronic navigational aids to confirm the D.R. position. Therefore, a coastal aids to navigation system must provide aids designed to allow for the navigational errors typical of the D.R. position accuracy of the least capable vessel using a site. This R calculation is often applicable not only to secondary landfall and coastal situations but to all sites (confined, coastal and landfall) at which distribution of aids to navigation lights must be such that vessels can be safely navigated in darkness and poor visibility conditions.

B. Non-Standard Compass/D.R. Radial Error

Radial Error using non-standard compass to steer and dead-reckoning alone: an error in D.R. position equal to 10% of the distance travelled since the last visually confirmed fix may be regarded as within the 99% confidence interval (in other words, there is a 99% probability that the vessel is located within this radial distance).

R = 10% of distance travelled or

$R = \frac{d}{10}$ nautical miles, where "d" is the distance between visually confirmed fixes.

C. Compliance Compass/D.R. Radial Error

Radial Error for Category 1 vessels using a compliance compass to steer, dead reckoning and with on board navigational aids (radar, etc.) for position accuracy: an error in position equal to 5% of the distance travelled since the last visually confirmed fix may be regarded as within the 99% confidence interval.

R = 5% of distance travelled or

$R = \frac{d}{20}$ nautical miles, where "d" is the distance between visually confirmed fixes.

C.6 Perception Gate (G)

The Perception Gate of an aid to navigation has been defined as the linear width, measured perpendicular to a line between a navigation aid and a hypothetical approaching vessel, that outlines the perception limits of that aid. The exceptions are where a parallel or oblique approach is being made to a land-based aid and the land thus interferes with the Gate. The location of other aids affects the calculation of the Perception Requirement. Thus the calculation of G depends upon the location of the aid and the type of approach.

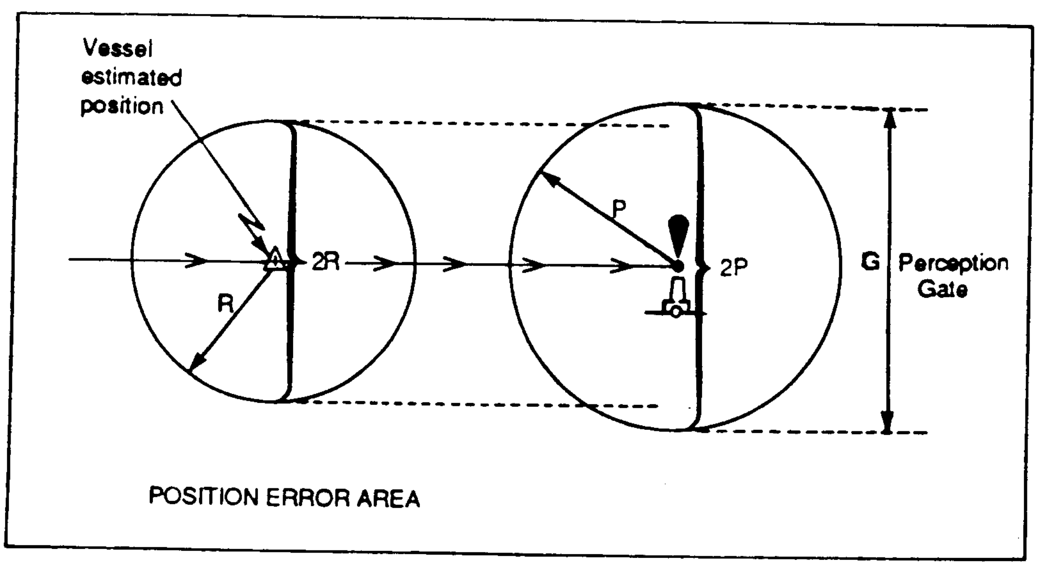
It has already been stated that perception of an aid to navigation by any approaching vessel will be successful when the perception area of that aid is larger than twice the approaching vessels "R", radius of position error. The actual calculation of this gate of perception, however, must be altered depending upon the location and type of the aid for which it is to be calculated.

C.6.1 Perception Gate for Fairway or Isolated Marker

Aids to Navigation that do not mark hazards and are approachable from all points of the compass (such as fairway buoys) do not have Danger Areas or require Safety Margins (Diagram 6). The perception gate (G) applicable is expressed by:

$$G = 2P$$
where $P \geq R$.

Diagram 6: Perception Gate for Fairway or Isolated Marker (no danger area or safety margin required).

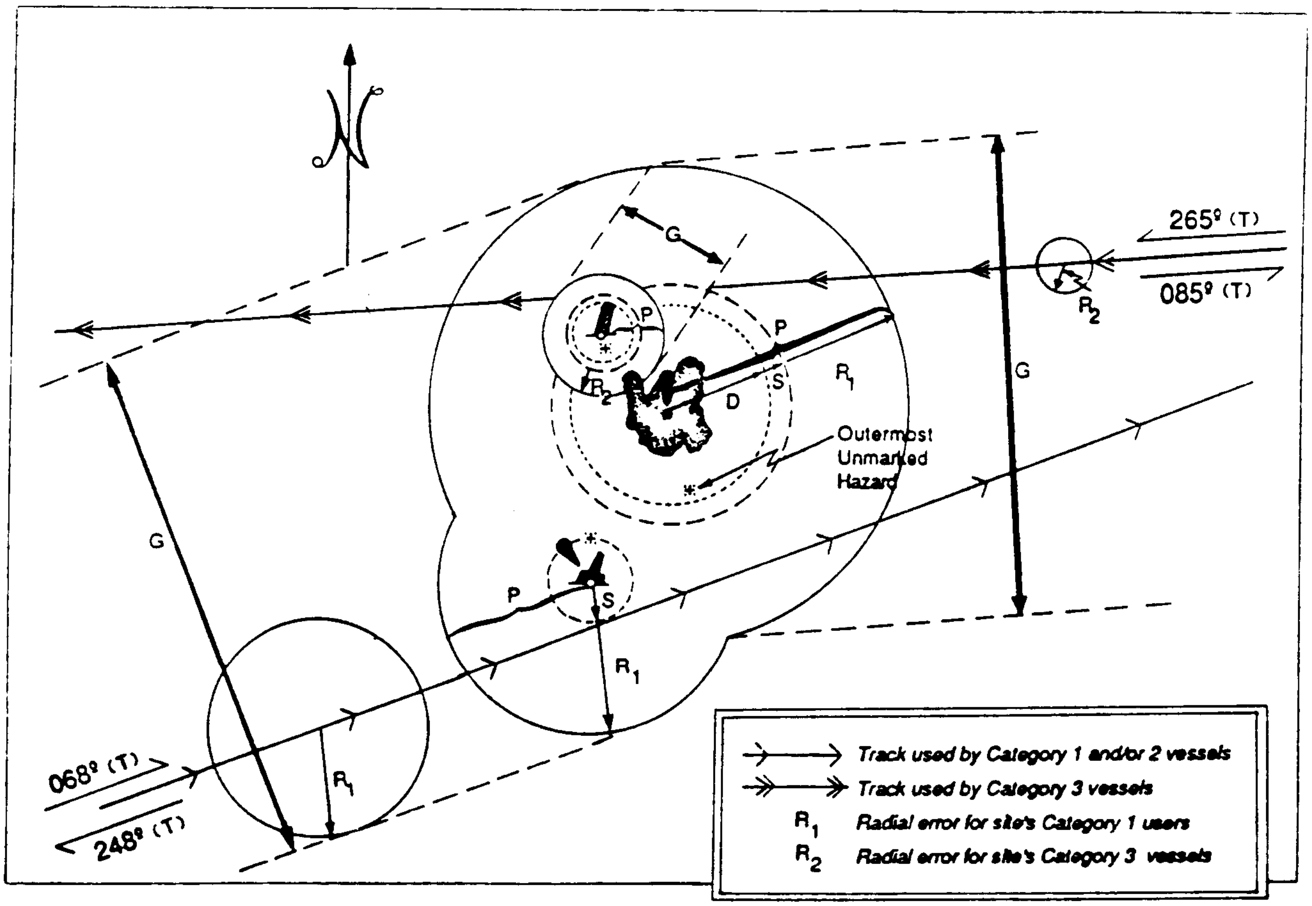


C.6.2 Perception Gate for Landfall With Outlying Hazards Marked

The perception gate (G) for an isolated hazard is similar to the fairway mark in that it may be approached from all points of the compass, however, the safety margin (S) and danger area (D) must be included (Diagram 7):

$$G = 2P$$
$$\text{where } P \geq R + D + S$$

Diagram 7: Perception Gate for Landfall With Outlying Hazards Marked

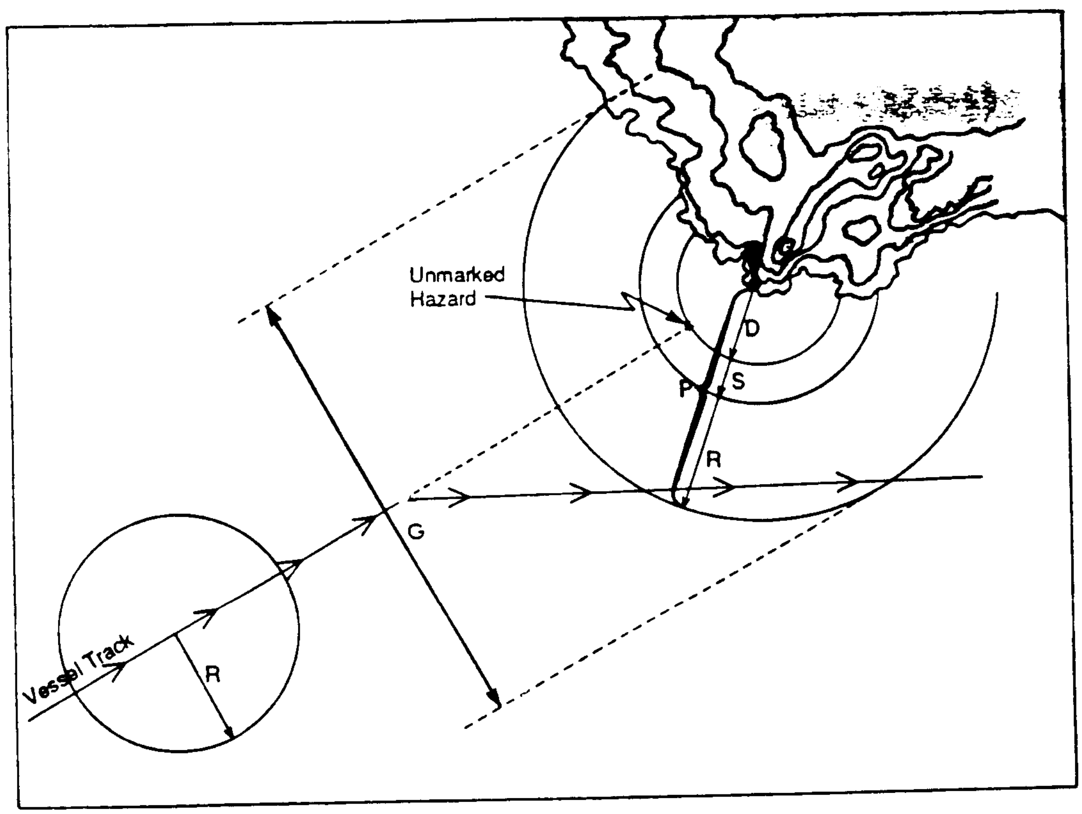


C.6.3 Perception Gate For Right Angle Coastal Approach

The Perception Gate (G) required for a right angle approach (obtaining visual contact with an aid to navigation when heading more or less straight for it and approximately at a right-angle to the coast) when the aid is located on a coast, is, by nature of its type and location, similar to that required by the isolated hazard (Diagram 8). The right angle-approached aid, such as a set of ranges, requires a perception gate as expressed by:

$$G = 2P$$
$$\text{where } P \geq R + D + S$$

Diagram 8: Perception Gate for Coastal Right Angle Approach

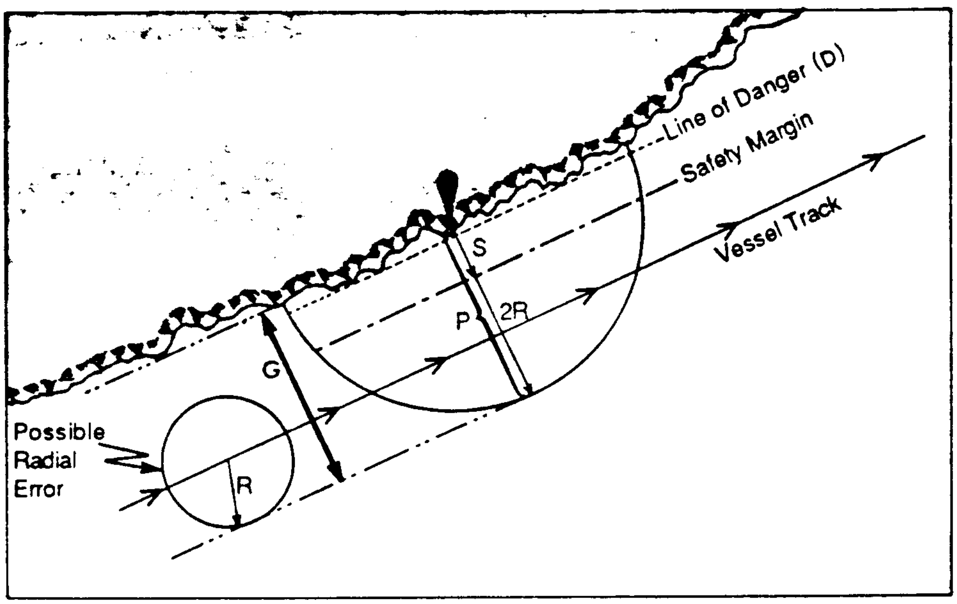


C.6.4 Perception Gate For Parallel Coastal Approach

The parallel approach to a coastal aid to navigation reduces the perception area by half (more or less due to impassable points of the compass caused by land). This doubles the requirement of radial error in the calculation of perception area, however, not the danger area or safety margin (Diagram 9). The width the required perception gate can thus be expressed by:

$$G \geq 2R + S + D$$

Diagram 9: Perception Gate For Parallel Coastal Approach



C.6.5 Perception Gate For Oblique Coastal Approach

Angular or oblique approaches to the coast are to be regarded as parallel approaches, to give the mariner benefit of the extra perception distance and because the oblique track is not a constant and cannot, in most cases be generalized.

C.7 Calculation of Perception Requirement (P): Summary

Perception Requirement, $P = R + D + S$,
where R = Radial Error:

Category I - Instrument Approach (Radar) $R = \sqrt{\sigma_1^2 + \sigma_2^2 ..}$ n. miles

where σ = deviation; and

- Compliance compass/D.R.

$$R = \frac{d}{20} \text{ n. miles}$$

where d = distance between fix and next visual mark.

Categories II & III - Non-standard compass/D.R.

$$R = \frac{d}{10} \text{ n. miles}$$

where d = distance between fix and landfall or next visual mark.

S = Safety Margin: Varies with the size of the vessel, as extracted from the Threat Guide Table included in this appendix. (Chart C-1).

D = Danger Area: Varies with the site and refers to the distance from the landfall mark to the outermost unmarked relevant hazard between the aid and the vessels approach.

C.8 Perception Gate Requirement (G): Summary

Fairway/Isolated Marks: $G = 2P$,
where $P \geq R$.

Isolated Hazards: $G = 2P$,
where $P \geq R + D + S$.

Coastal Approaches

Right Angle: $G = 2P$,
where $P \geq R + D + S$

Parallel Approach: $G \geq 2R + D + S$.

Oblique Approach: Calculate as for a Parallel Approach to give mariner benefit of extra perception area.

C.9 Conclusion

This appendix describes the necessary perception gate calculations for landfall and point-to-point (secondary landfalls) navigation. In addition to these, however, are the coastal and confined waters pilotage situations, to which many of the preceding principles apply. The application of D.R. radial error (in which the greater the distance travelled after a confirmed position and before a visual aid comes into view, the larger the vessel's radial error becomes) applies to the perception of aids when piloting. This concept is expanded upon in the examples under preparation for Operational Analysis of both open and confined waters.

The actual determination of the perception area and perception gate for an aid or aids system requires the application of the knowledge of experienced mariners, local knowledge and careful application of the guidelines in this manual to each situation. Consideration of these factors will provide for an assessment of an accurate and adequate Perception Requirement. With this figure in hand, the aids system designer can determine which aids or combination of aids will meet the prescribed level of service and which are most practical.

C.9 PERCEPTION REQUIREMENTS AND LANDFALL GATES FROM THE USER'S VIEWPOINT

To understand how the "R", "S", & "D" values are used to establish the perception requirement and thence determine the aid to navigation coverage requirement for successful landfall, it may help to consider the problem from the viewpoint of the user. Much of the information is a repeat of the preceding sections, from a different perspective.

Landfall is the first confirmation of position after a voyage on which there was some uncertainty of position. This uncertainty is two dimensional in that the mariner can be ahead or behind (along track) and to the left or right (cross track) of the estimated position. Successful landfall occurs when vessel position is determined in sufficient time for hazards to be avoided. What this means in terms of the mariners needs is that he requires positioning information which will enable him to eliminate his left/right position uncertainty in sufficient time to allow manoeuvering to avoid the hazards ahead of him.

CROSS TRACK

The component of radial error that is perpendicular to the direction of a vessel's intended track is known as cross track error. As a vessel can be either to port or starboard of the intended track, it can be seen that the total possible width of this error is twice the radial error, or 2R. Landfall should be successful if a signal can be provided to the mariner over the width 2R at a range sufficiently distant from any charted hazard to allow course correction or evasive manoeuvres to be completed.

While 2R describes the width of the likely (99% of occasions) cross track error, the requirements of the mariner are not for a rectangle or straight band of light in front of his vessel at the point of landfall. This "strip" of coverage that is necessary is in effect "curved" towards the approaching vessel to allow for the position uncertainty caused by his along track error.

ALONG TRACK

The values D, S, & R interrelate to provide the perception requirement "P", which varies according to the type of landfall (i.e. safe water no hazard, isolated hazard, solid wall hazard) and according to the angle of the approach to the landfall.

The values "D" and "S" have a constant relationship in that if "D" does not exist, neither does "S" and that where "D" exists, "S" can be added to "D" and their sum serves to produce the outer limit of the safety margin.

When landfall is made in a safe water situation and dangers do not exist (i.e. on a buoy), no allowance has to be made for hazards and the perception requirement breadth will approximate 2R. This applies to any angle of approach for the open water landfall. See diagram 10.

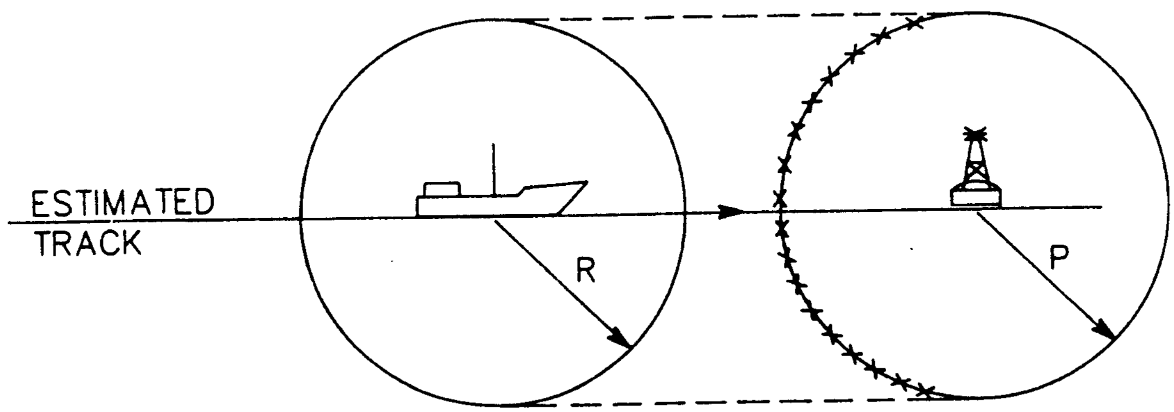


Diagram 10 - Safe water landfall

If $2R$ is $\leq 2P$, landfall should be successful. The mariner will expect to perceive the aid by the hatched line. This is the actual coverage required for landfall for the illustrated vessel.

For a landfall on an isolated danger, such as an island or a point of land, allowances have to be made for "D" and "S". The gate width requirement is still 2R but the gate will be needed further off the landfall aid in case the vessel is standing directly onto the danger (and an evasive manoeuvre is required) or in case the aid has ceased functioning (to provide time for the mariner to come to this realization).

Diagram 11 illustrates an approach to an isolated danger on an island. The "gate width" requirement is 2R, but to allow for the worst case, when the vessel is standing onto the hazard and the aid has been inadvertently extinguished, the mariner should see or hear the landfall aid D + S + R distant from the aid (point 0).

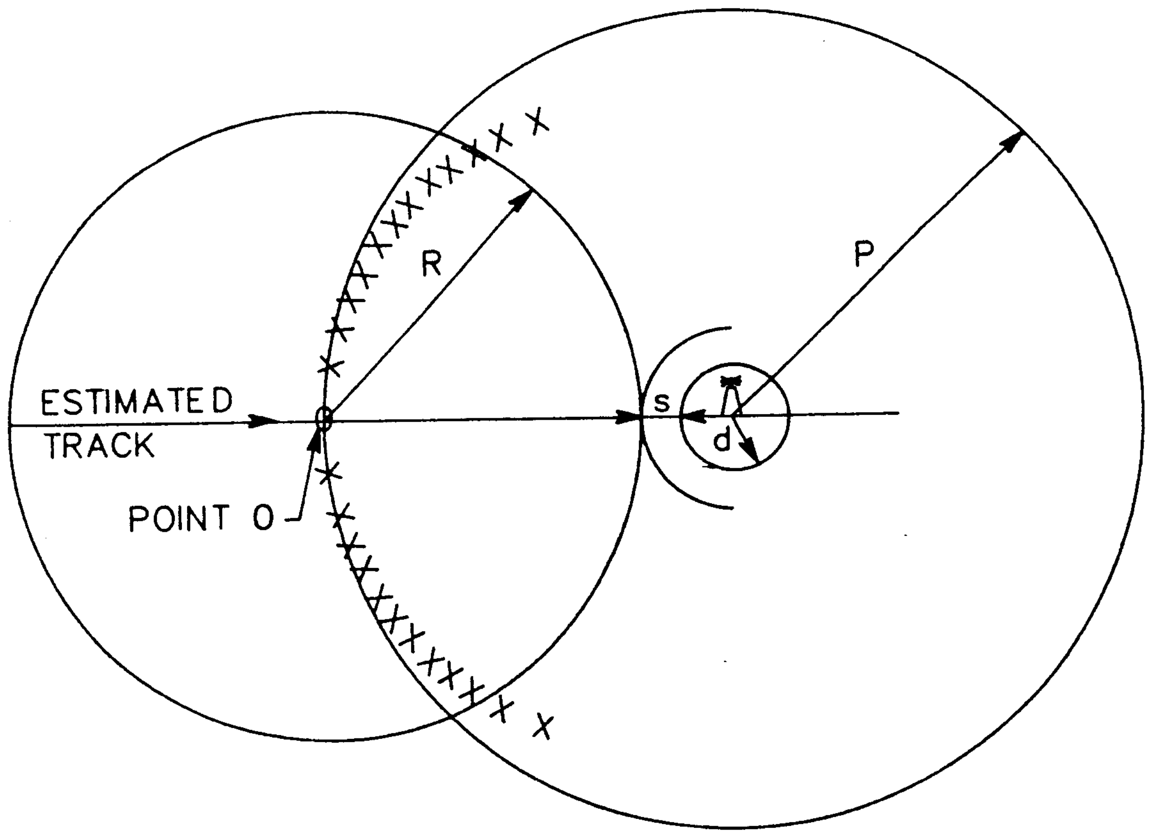


Diagram 11 - Approaching a light on an isolated danger

The greatest (furthest point from light source) requirement for "P" is at point Q, d + s + R distant from the light. Mariners will expect to perceive the aid by the hatched line. This is the actual coverage required for landfall.

Diagram 12 illustrates an approach to an isolated danger located on a headland. Note the mariner will have adjusted his estimated track to starboard to ensure that his uncertainty of position (R) will not take him into danger (line Y) before he should have perceived the landfall aid. His gate width requirement is again 2R and his perception requirement P is still D + S + R. It can be seen that if his estimated route had been directly at the landfall aid and he so happened to be at point X in his radial error circle, when be perceives the aid and is able to confirm his position, it will have been too late, as he will be within the danger contour line and will have run onto the hazard.

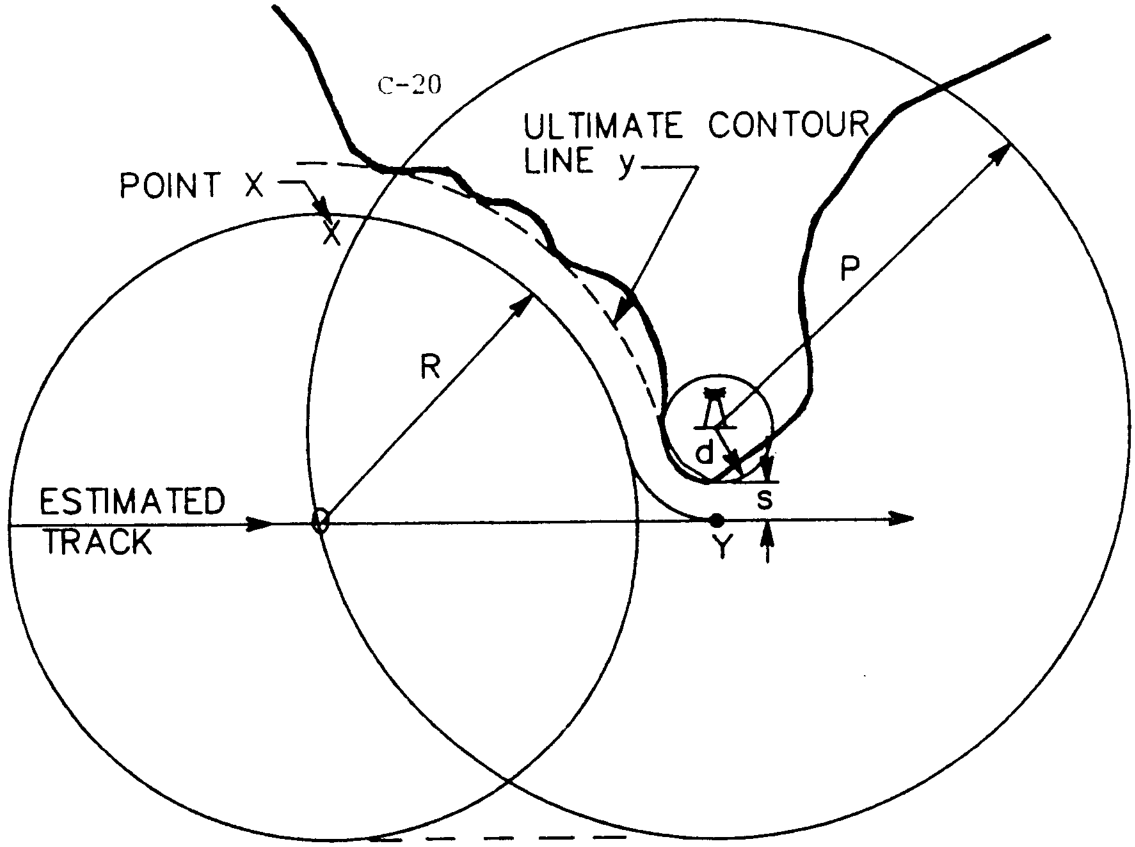


Diagram 12 - Approaching a light on an isolated danger located on a headland

The greatest (furthest point from light source) for "P" is at point "0" d + s + R away from the light. It can be seen that if the estimated track is moved to starboard (off the safety margin), "P" will grow by that same amount. Thus the formula for P becomes d + s + R + the distance from the outer limit of the safety margin to the design track.

When the danger contour line flattens until the coastline becomes straight, as in diagram 13, the prudent mariner will plan his route (to maintain his estimated track) so that when he arrives off the landfall aid (point Y), he will still have an allowance for D and S between himself and the landfall aid, plus an allowance equal to his potential radial position error in case there has been a cross-track component to port, equal to R, in his dead reckoned position. The landfall aid will have to reach point P to satisfy the perception requirements of the mariner who happens to have a cross-track radial error equal to R to starboard of his estimated track. Therefore the landfall aid illustrated will have a range equal to D + S + 2R to reach "P" and satisfy 99% of radial error possibilities.

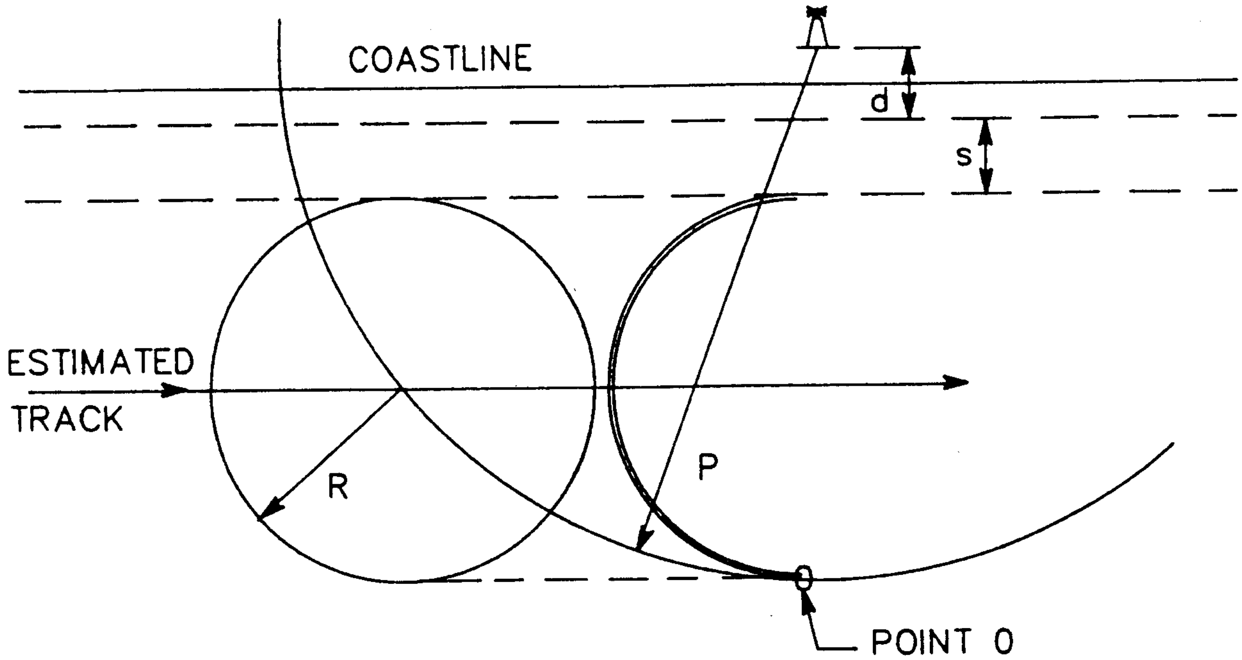


Diagram 13 - The parallel approach

The greatest requirement (furthest point form light source) for "P" will be at point "0", d + s + 2R distant from the lightstation. The broad band outlines the actual coverage required for successful landfall.

Diagram 14 illustrates a right angle approach to a landfall aid on a straight coastline. Mariners dislike a right angle approach to a hazard because it leads straight onto the hazard and a larger alteration in course is required to avoid the hazard than with an oblique approach. However, the right angle approach may be the worst-case scenario and therefore demand the greatest "P" requirement. The maximum width of the cross-track error is still 2R, and to accommodate the potential along track error plus allow for "D" and "S", the landfall aid will have to be perceived at point ~~X~~ O. This range or "P" requirement is equal to D + S + 2R.

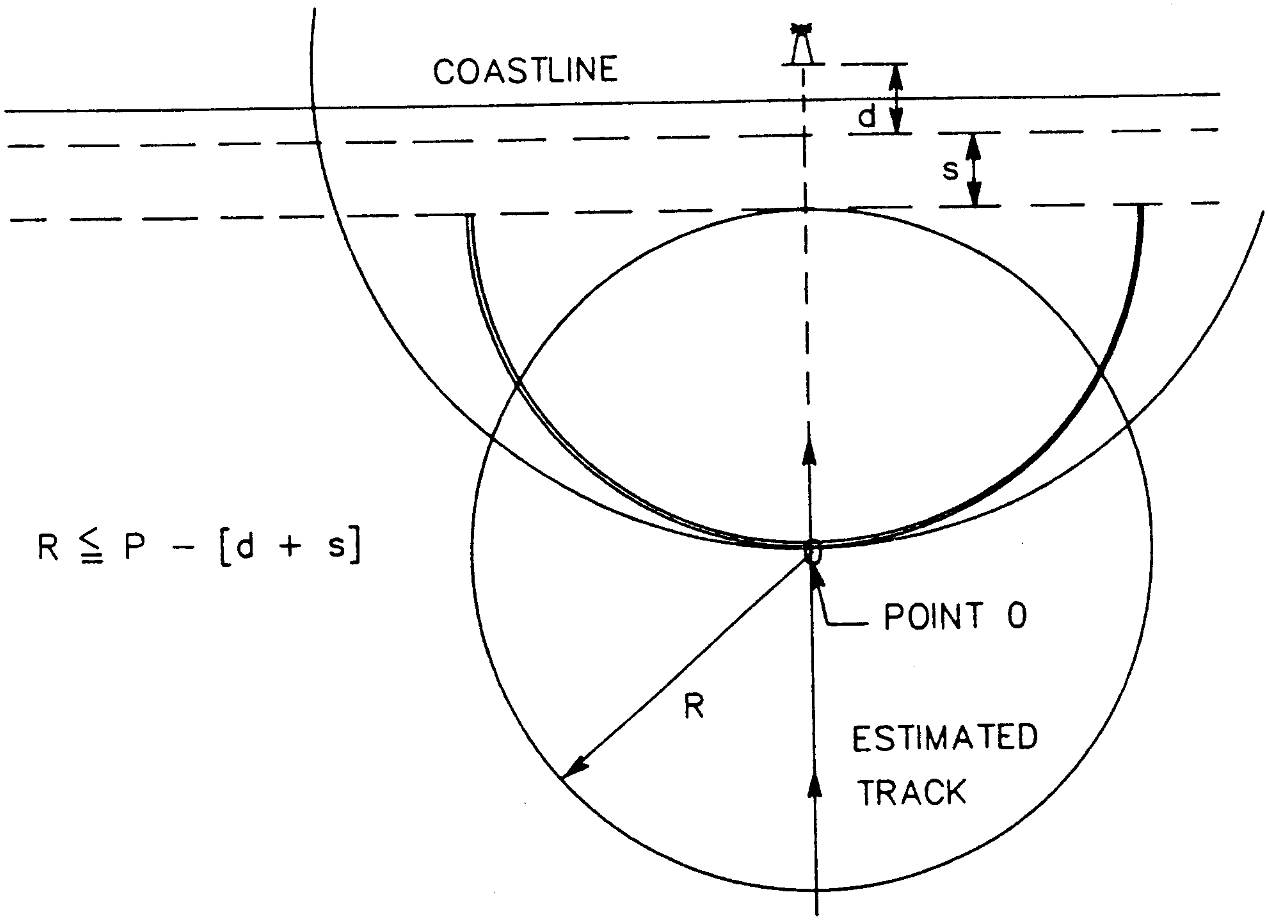


Diagram 14 - The approach at right angles

The greatest requirement (furthest point from light source) for "P" will be at point "0", d + s + R distant from the light station. The broad band outlines the actual coverage required for successful landfall.

The "P" requirement formula for an oblique approach to the straight coast will be somewhere between the P > D + S +2R required for a parallel approach and the P > D + S +R required for a right angle approach. However as there are an infinite variety of coastlines and approach angles, every situation will be slightly different. Normally though if the mariner is provided with a landfall aid coverage width at least as large as his 99% probable cross-track error component, far enough out from the hazards to allow course correction to be made, landfall should be successful.

Diagram 15 illustrates a landfall design situation where one hazard is present outside of the "D" margin and another is outside the "D" + "S" allowance. These two hazards are marked with aids to navigation that provide coverage greater than the "D" + "S" requirement and therefore do not have to be included behind the danger line.

Diagram 15 also illustrates a landfall situation that, typical of the real world, is in between the textbook examples previously examined. There are two hazards within the landfall area that have not been included behind the danger line because they are individually marked. The estimated track is offset from the landfall aid and is off the safety allowance as well. This produces a "P" requirement that is not greatest at point "O", but at the two points "X".

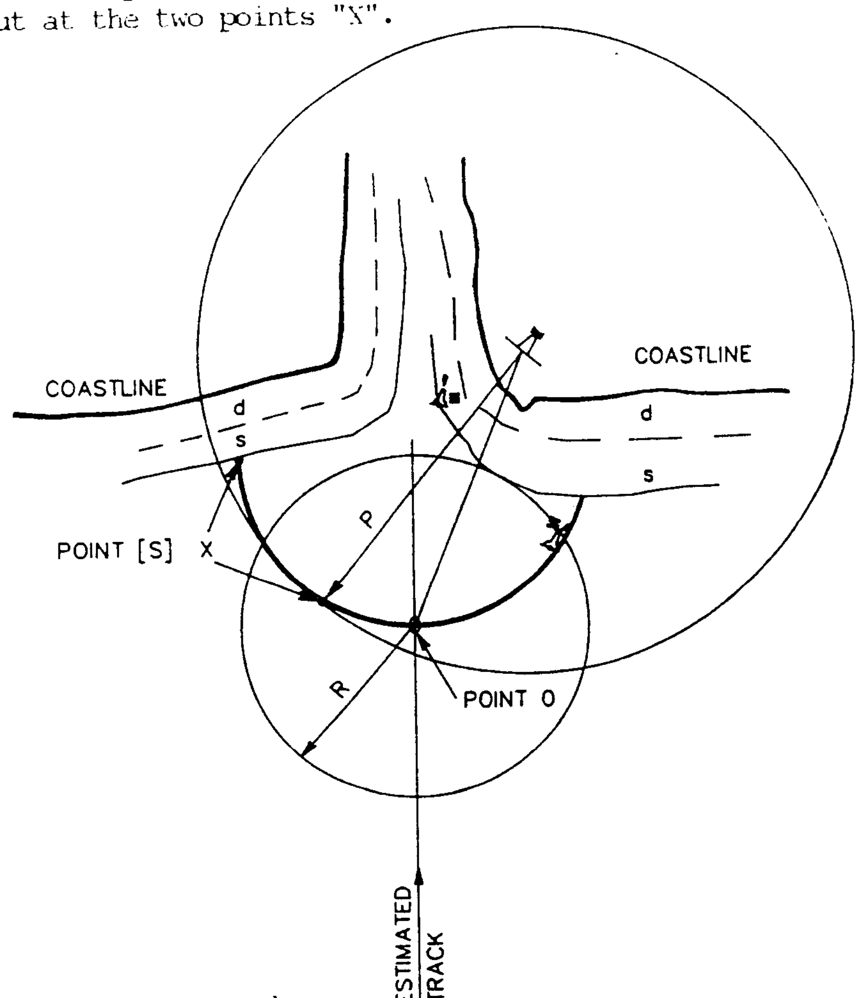


Diagram 15 - Relevant Hazards on Approach

The greatest (furthest points from the light source) requirement for "P" will be at the points marked "X", not at point "O". The broad band outlines the actual coverage required for successful landfall. If this is to be provided solely by the lightstation illustrated, the coverage required will be as shown by the large circle.

Sound signals

When in restricted visibility visual means are incapable of warning the mariner of his proximity to a coastal light and the dangers by which it is surrounded, sound signals may usefully be employed. It is logical to assume that the sound signals should be so powerful that they can be heard at least at a range equal to $(d - s)$. It may also be assumed that in fog a navigator would never approach a danger at a relatively high speed and consequently the value of s should be related to the distance needed by a slowly approaching ship to avoid the danger once the fog signal has been perceived and identified.

The actual ranges attained by fog signals are very limited and it is imperative therefore that efforts are made to keep d small. This means that the signal emitter should be mounted as close as possible to the edge of the danger area.

It is basically dangerous to rely on hearing a fog signal when to windward of the emitter. Marking the danger area within the landfall gate with sound buoys is therefore a sensible precaution, in particular when the bottom profile of the sea is steep-to, giving no indication of the nearness of the dangers.

Sound signals are common on coastal buoys: whistle-buoys and bell-buoys. Because the power of these sound signals is not very great and their action is dependent on the wave motion, which is usually least when visibility is restricted, electric fog horns are being considered for use.

Use of Buoys for Landfall

It is common to place a lighted sound fairway buoy at the seaward end of an approach channel. This buoy not only assists in the process of alignment when the approach channel is provided with a leading line, but serves as an aid for making landfall. Where the buoy can remain on but serves as an aid for making landfall. Where the buoy can remain on station all year, it reduces the need for high-powered lights and fog signals to provide landfall coverage requirements only from shore.

The appropriate cardinal or lateral buoys may also be strategically placed within the perception (P) required to provide landfall in addition to and in some instances in place of shore aids keeping in mind these perception requirements from the mariners viewpoint will greatly assist the system design, particularly in determining the placement and coverage requirements of buoys to aid landfall.

Because of the oscillations of a lightbuoy in a coastal situation a buoy showing a flashing character will not normally be first perceived at its luminous range but a shorter distance.

In daytime buoys are best distinguished when seen above the horizon. Navigators on a high bridge are therefore at a disadvantage. An observer with a height of eye of 20 m for example will have the top of a daymark of 3 m height in line with the horizon when he is still 5.7 n. miles distant. When approaching the buoy it depends upon the contrast of the daymark against the background of sea water at which range it will come in sight. The contrasts may change with time of day and direction of the sun. A visual range of 2.5 n.miles may normally be expected of buoys in coastal navigation.

Since the ranges at which lightbuoys may be perceived in daytime as well as at night, are so limited, the radar reflector has become almost standard equipment on buoys employed in coastal navigation.

Unlighted buoys for coastal navigation

The use of unlighted buoys for coastal navigation is limited because in most applications lightbuoys will perform the required function both by day and in darkness.

Unlighted buoys are primarily employed in coastal areas where shipping density does not warrant the establishment of a complete lighting system and where navigation is practised only by day. In such areas navigation is carried out with the aid of natural landmarks, supplemented where necessary by fixed marks.on land and by unlighted buoys to mark submerged dangers.

In daylight a lightbuoy may be detected at something like half the range at which it can be seen at night. Lightbuoys which are positioned in such a manner that a danger is adequately covered in darkness may therefore have a spacing which is too wide for daylight; the gaps may be filled by unlighted buoys. Due care is normally taken that the unlighted buoys are not likely to be run over by a ship which proceeds from lightbuoy to lightbuoy in darkness; for this reason the unlighted buoys are normally positioned a little to landward of the lines connecting the successive lightbuoys.

Unlighted buoys for coastal navigation should be visible at relatively great distances and therefore have dimensions comparable to those of lighted buoys (0 > 2 metres).

Unlighted buoys may be used as special marks for a variety of purposes, such as spoil ground marks, military exercise zone marks, cable or pipeline marks and recreation zone marks. The buoys may be unlighted if they do not form a hazard to shipping in darkness.

C10 Effect of Background Lighting on Nightime Landfall Design

It is generally accepted that minor background lighting at night reduces the effective intensity of a light by a factor of 1/10 and that considerable background lighting will reduce the effective intensity by a factor of 1/100.

This reduction is amplified when landfall lights are coloured to make them distinctive against the background lighting. The multiplying factor for coloured lenses varies by lense size, type and material. It can be seen in the technical tables in appendix A that the factor averages about 0.25 for red and green and about 0.60 for yellow.

Although the non-navigational background lights may provide assistance in indicating the intended destination, they usually lack the distinctiveness required to provide positioning information, particularly for mariners without good local knowledge. The landfall aids to navigation system designer should make the necessary allowances for the decrease in effective intensity of aids to navigation lights when background lighting is present.

C11 Daylight Landfall Design

When making land in daylight in good visibility the mariner usually has an increasing number of landmarks at his disposal to fix his position as the distance to the coast decreases.

Navigational dangers may be spotted visually and submerged dangers may sometimes be detected by seeing breakers or discoloured patches before it is too late, even in moderate visibility. Therefore landfall in daylight is generally considered safer than it is at night. On the other hand, some coasts are entirely featureless or low and the provision of daymarks may be indispensable. Lighthouses cannot be seen in daylight at ranges anywhere near their nighttime luminous range; outlying dangers which are invisible in daytime but which are covered at night by the coastal lighting system may have to be marked with buoys or beacons for the safety of ships making land in daylight.

Light buoys will also not be detected visually by daylight at the geographical range of their light but generally at much smaller distances.

APPENDIX D: USER QUESTIONNAIRE

1. This questionnaire should be completed by the interviewer, for a representative number of users for each site review. The answers will assist in identifying the users as well as assist and test the analysis of the site. The information will also provide an ongoing review of the factors contained in this manual, and provide contacts for future site reviews.

2. Questions 1 to 5 incl. will assist or test the completion of the Site Data Sheet 73-0115 and the Preliminary Threat Rating Sheet 73-0118.

3. Question 6 is designed to test or assist the marking of the track on the chart and the completion of the Threat Rating and Comments columns of the Needs Matrix forms 73-0119 & 73-0120.

4. Question 7 is designed to test the user impact of the level of service provided in terms of the meteorological visibility used to design the visual system to meet the percentage availability intended.

5. Question 8 will test the user impact of the design wind speed used to meet the percentage availability of established or proposed land-based fog signals.

6. Question 9 will collect any general comments.

7. Question 10 should provide a source for further user input.

CYCLICAL REVIEW SITE QUESTIONNAIRE

District/Region: ____________ Chart No. ____________ Site: ____________
Interviewer: ____________ Date: ____________ File No: ____________
Person Interviewed: ____________ Address: ____________________
____
Telephone: ____________

1. What is your User Category.

☐ I — Certificated operator or pilot (class IV Fishing master certificate or higher), vessel equipped with radar, standard compass and other on-board aids according to Navigating Appliances Regulations.

☐ II — Operator of a local commercial vessel such as a tug, tour boat or fishing vessel.
 ☐ Equipped with Radar
 ☐ Class IV Fishing Master Certificate or higher.

☐ III — Pleasure Craft Operator.
 ☐ Equipped with compass
 ☐ Equipped with searchlight.

2. Do you operate at night ☐ yes ☐ no

3. What is your season of operation ____________ to ____________
App. day/Month   Appr. day/Month

4. Size and type of largest vessel you operate at the site:

Length ____________ Gross Tonnage ____________ Beam ____________
Draft ____________ General Type ____________________.

5. Estimate the numbers of vessels using this site, the number of transits (one-way trips) and the percentage operating at night.

Number of Users		Number of Transits	Night Use
I ________	certified commercial carriers	________	________%
II ________	local commercial fishermen, tugs, etc.	________	________%
III ________	pleasure craft	________	________%

6. Identify Threats at the Site. (Interviewer will present largest scale chart(s))
   a) Mark your usual track on the chart where required, indicating furthest distance traveled from shore.
   b) With the present aids to navigation system in place, identify areas at the site where any of the following threats exist or could exist for your vessel (where you have ever felt at risk). Write the corresponding number on the threat locations on the chart and check off the threat on the list.

- ☐ 1. too close to a hazard
- ☐ 2. too close to other vessels
- ☐ 3. channel too narrow
- ☐ 4. angle of turn too sharp
- ☐ 5. traffic too dense
- ☐ 6. lack of distinctive visual feature to aid landfall or fix position
- ☐ 7. lack of distinctive radar features
- ☐ 8. frequent strong winds
- ☐ 9. frequent high waves/swells
- ☐ 10. strong along-track current
- ☐ 11. strong cross-track current
- ☐ 12. darkness
- ☐ 13. reduced visibility
- ☐ 14. siltation in the channel
- ☐ 15. ice and/or freezing spray

7. Identify on the chart any aids to navigation that you feel should be improved, added or discontinued.

8. What levels of reduced visibility would you consider unsafe to use this waterway. Assume all the aids to navigation are in working order.

- ☐ zero visibility
- ☐ ¼ nautical mile
- ☐ ½ nautical mile
- ☐ 3/4 nautical mile
- ☐ 1 nautical mile
- ☐ 2 nautical mile
- ☐ 3 nautical mile

or: ☐ I can operate safely at zero visibility at this site.

9. (Ask this question only where fog signals are located or proposed on shore). What levels of onshore wind speeds would you consider unsafe to use this site.

☐ 5 knots ☐ 10 knots ☐ 15 knots ☐ 20 knots ☐ 30 knots ☐ 40 knots

10. Any general comments concerning the aids to navigation system at this site.

11. Name / Address / Phone No. of other users of this site that could be interviewed.

RECOMMANDATION POUR UNE DÉFINITION DE LA PORTÉE NOMINALE DE JOUR DES FEUX DE SIGNALISATION MARITIME CONÇUS POUR GUIDER LES NAVIRES DE JOUR

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Avril 1974

Extrait du Bulletin de l'AISM, n° 60 – 1974-3

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RECOMMENDATION FOR A DEFINITION OF THE NOMINAL DAYTIME RANGE OF MARITIME SIGNAL LIGHTS INTENDED FOR THE GUIDANCE OF SHIPPING BY DAY

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April 1974

Extract from IALA Bulletin, n° 60 – 1974-3

ASSOCIATION INTERNATIONALE DE SIGNALISATION MARITIME
INTERNATIONAL ASSOCIATION OF LIGHTHOUSE AUTHORITIES
43 Avenue du Président Wilson – 75.116 Paris

RECOMMANDATION POUR UNE DÉFINITION DE LA PORTÉE NOMINALE DE JOUR DES FEUX DE SIGNALISATION MARITIME CONÇUS POUR GUIDER LES NAVIRES DE JOUR

Avril 1974

La "Commission de la Notation de l'intensité lumineuse et de la portée des feux" (Président: M. P. Blaise) a été créée le 30 septembre 1960. Ses travaux ont abouti à la définition d'une portée nominale des feux définie par la "Recommandation pour la Notation de l'intensité et de la portée des feux" qui a été approuvée le 16 novembre 1966 par le Comité Exécutif de l'AISM et publiée dans le no 32 – Avril 1967 de ce Bulletin.

Les Résolutions B 128 – "Indication de la portée des feux" et D 14 – "Portées nominale, lumineuse et géographique" de la 10ème Conférence Hydrographique Internationale (Monaco 1970) ont introduit cette notion de portée nominale dans les documents officiels de l'Organisation Hydrographique Internationale.

Toutefois cette Recommandation de l'AISM ne considérait que l'usage des feux de nuit. Or des feux de signalisation maritime conçus pour guider les navires de jour ont été récemment mis en service dans divers pays. Le problème de la détermination de leur portée et de l'indication à donner aux navigateurs quant aux performances qu'ils peuvent en attendre s'est alors posé.

Il paraissait d'autre part souhaitable de fixer dans un délai assez court des valeurs de référence utiles aux travaux d'autres commissions comme la "Commission du Calcul de l'intensité lumineuse des feux".

Une enquête a alors été effectuée auprès des membres de la "Commission de la Notation de l'intensité lumineuse et de la portée des feux" sur l'opportunité d'un examen du problème de la définition d'une portée nominale de jour pour les feux de signalisation maritime utilisés de jour. Des avis favorables ayant été formulés, la Commission a repris ses travaux au mois de novembre 1972 et a préparé la Recommandation ci-après qui a été approuvée par le Comité Exécutif le 25 avril 1974.

RECOMMENDATION FOR A DEFINITION OF THE NOMINAL DAYTIME RANGE OF MARITIME SIGNAL LIGHTS INTENDED FOR THE GUIDANCE OF SHIPPING BY DAY

April 1974

The "Committee on the Notation of luminous intensity and range of lights" (Chairman: Mr. P. Blaise) was set up on the 30th September, 1960. Its work led to the definition of a nominal range of lights defined by the "Recommendation for the Notation of luminous intensity and range of lights" which was approved on the 16th November 1966 by the Executive Committee of IALA and published in this Bulletin, no 32 – April 1967.

Resolutions B 128 – "Indication of the range of lights" and D 14 – "Nominal, luminous and geographical ranges" of the 10th International Hydrographic Conference (Monaco 1970) introduced the idea of nominal range into the official documents of the International Hydrographic Organisation.

However in that IALA Recommendation consideration was given only to the use of lights by night. Now recently, in various countries, maritime signal lights have been put into service, especially for use by day. There therefore arose the question of the determination of their range and how to indicate navigators the performance they may expect from such lights.

Furthermore, it appeared desirable to agree, with as little delay as possible, reference values useful for the work of other committees such as the "Committee on the Calculation of luminous intensity of lights".

A questionnaire was therefore circulated to the members of the "Committee on the Notation of luminous intensity and range of lights" on the possibility of examining the problem of definition of a nominal daytime range for maritime signal lights used by day. Favorable opinions having been expressed, the Committee took up its work again in the month of November, 1972 and prepared the following Recommendation which was approved by the Executive Committee on the 25 April 1974.

L'Association Internationale de Signalisation Maritime recommande:

1) de définir comme suit la portée nominale de jour des feux de signalisation maritime conçus pour guider les navires de jour:
"La portée nominale de jour d'un feu de signalisation maritime est la distance en milles marins à laquelle ce feu présente un éclairement sur l'oeil de l'observateur de $1\ 10^{-3}$ lux dans une atmosphère homogène par une visibilité météorologique de 10 milles marins";

2) de publier dans les "Livres des feux" la portée nominale de jour des feux conçus pour guider les navires pendant le jour;

3) de publier dans les "Livres des feux" un graphique du modèle ci-joint (Annexe I) permettant aux navigateurs d'évaluer la portée lumineuse des feux de jour en fonction de leur portée nominale de jour, de la visibilité météorologique et de la luminance du ciel dans la direction d'observation.

2

La détermination de l'intensité lumineuse en fonction de la portée lumineuse est effectuée en admettant que la visibilité météorologique correspond à un seuil de contraste de 0,05 tel que normalisé par l'Organisation Météorologique Mondiale d'où la formule:

$$I = Ex^2 (0{,}05)^{-\frac{x}{V}}$$

où x est la portée lumineuse, V la visibilité météorologique, E le seuil d'éclairement et I l'intensité lumineuse, toutes les grandeurs étant exprimées en unités du système international (SI).
L'intensité lumineuse en candelas correspondant à une portée nominale de jour x' en milles marins est alors donnée par:

$$I = 3430\ x'^2\ (20)\ 0{,}1\ x'$$

Le graphique de l'Annexe I est établi en admettant que le seuil d'éclairement E en lux produit par un feu dépend de la luminance L du ciel en candelas par mètre carré dans la direction d'observation selon la formule:

$$E = 0{,}242\ 10^{-6}\ (1 + \sqrt{0{,}4\ L})^2$$

Le seuil de $1\ 10^{-3}$ lux correspond ainsi à une luminance de ciel de 10 000 candelas par mètre carré.

The International Association of Lighthouse Authorities recommends:

1) that the nominal daytime range of maritime signal lights intended for the guidance of shipping by day should be defined as follows:
"The nominal daytime range of a maritime signal light is the distance in sea-miles at which this light produces an illuminance at the eye of the observer of 1×10^{-3} lux in a homogenous atmosphere with meteorological visibility equal to 10 sea miles";

2) that the nominal daytime range of lights intended for the guidance of shipping by day should be published in the "Lists of Lights";

3) that there should be published in the "Lists of Lights", a graph of the type attached (Appendix I), permitting navigators to calculate luminous range of lights by day, as a function of their nominal range by day, of the meteorological visibility and of the sky luminance in the direction of observation.
The determination of the luminous intensity as a function of the luminous range is based on the assumption that the meteorological visibility corresponds to a threshold of contrasts of 0.05, as standardised by the World Meteorological Organisation, hence the formula:

$$I = Ex^2 (0.05)^{-\frac{x}{V}}$$

in which x is the luminous range, V the meteorological visibility, E the threshold of illuminance and I the luminous intensity, all quantities being expressed in units of the international system (SI).
The luminous intensity in candelas corresponding to a nominal daytime range x' in sea miles is thus given by:

$$I = 3430\ x'^2\ (20)\ 0.1\ x'$$

The graph of Appendix I is obtained on the assumption that the threshold of illuminance E in lux, produced by a light, depends on the luminance L of the sky in candelas per square metre, in the direction of observation, according to the formula:

$$E = 0.242\ 10^{-6}\ (1 + \sqrt{0.4\ L})^2$$

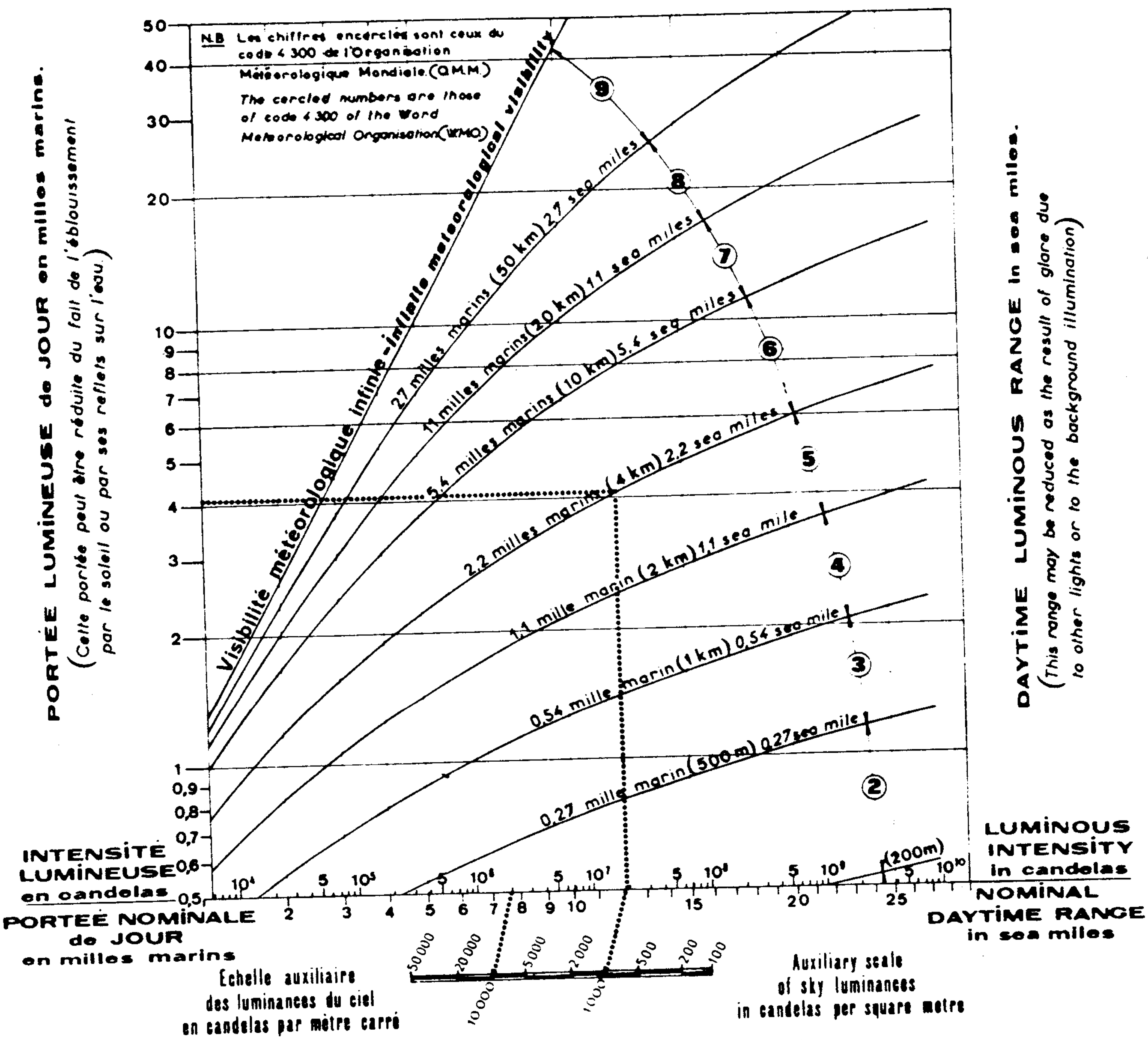
The threshold of $1.\ 10^{-3}$ lux thus corresponds to a sky luminance of 10,000 candelas per square metre.

ANNEXE I - APPENDIX I

Graphique de portée lumineuse de jour

Graph of daytime luminous range

(Voir le mode d'utilisation, page 4 – See how to use the graph, page 4)



Ciel couvert très sombre – 100 cd/m² – Very dark overcast sky
Ciel couvert sombre – 200 cd/m² – Dark overcast sky
Ciel couvert ordinaire – 1 000 cd/m² – Ordinary overcast sky
Ciel couvert lumineux, ciel clair loin du soleil – 5 000 cd/m² – Bright overcast sky or clear sky away from the direction of the sun
Nuage brillant, ciel clair près du soleil – 10 000 cd/m² – Bright cloud or clear sky close to the direction of the sun
Nuage très brillant – 20 000 cd/m² – Very bright cloud
Nuage éblouissant – 50 000 cd/m² – Glaring cloud

Mode d'utilisation du graphique – Ce graphique est tracé pour une luminance du ciel de 10 000 cd/m². Pour d'autres valeurs de la luminance du ciel, se décaler sur l'échelle des abscisses de l'écart entre la luminance de 10 000 cd/m² et celle considérée tel qu'il se présente sur l'échelle auxiliaire. Pour les feux à éclats brefs, l'intensité lumineuse à prendre en compte est l'intensité effective.

Exemple: Soit à calculer la portée lumineuse d'un feu de 2 000 000 candelas par 2,2 milles marins (4 km) de visibilité météorologique avec un ciel couvert ordinaire (luminance de 1 000 cd/m²).

Mesurer l'écart qui sépare les graduations 10 000 et 1 000 sur l'échelle auxiliaire. Reporter cet écart sur l'échelle des abscisses à partir de la graduation 2 10^6 cd dans le même sens; on obtient un point légèrement à droite de la graduation à 12 milles marins. Elever de ce point une parallèle à l'axe des ordonnées jusqu'à la courbe 2,2 milles marins. Lire la portée lumineuse sur l'échelle en face du point obtenu. On lit 4,1 milles marins.

Use of the graph – The graph has been drawn for a sky luminance of 10,000 cd/m². For other values of sky luminance mark off along the scale of abscissae the distance between the luminance of 10 000 cd/m² and that under consideration as it appears on the auxiliary scale. For short duration flashes, the luminous intensity to use is the effective intensity.

Example: Suppose that it is required to calculate the luminous range of a light of 2,000,000 cd for a meteorological visibility of 2.2 sea miles (4 km) under an ordinary overcast sky (luminance 1,000 cd/m²).

Measure the distance separating graduations 10,000 and 1,000 on the auxiliary scale. Transfer this distance to the scale of abscissae from the graduation corresponding to 2.10^6 cd in the same sense, and a point slightly to the right of the graduation corresponding to 12 sea miles is obtained. Erect from this point a parallel to the axis of ordinates to meet the curve for 2.2 sea miles visibility. Read off the luminous range on the vertical scale against the point so obtained. We read 4.1 sea miles.

ANNEXE II - APPENDIX II

Tableau de conversion de la portée nominale de jour en intensité lumineuse

Conversion table from nominal daytime range to luminous intensity

Portée nominale *Nominal range*	Intensité lumineuse *Luminous intensity*	Portée nominale *Nominal range*	Intensité lumineuse *Luminous intensity*	Portée nominale *Nominal range*	Intensité lumineuse *Luminous intensity*
milles marins *sea miles*	kilocandelas *(10^3 cd)*	milles marins *sea miles*	megacandelas *(10^6 cd)*	milles marins *sea miles*	megacandelas *(10^6 cd)*
1	4,6	7	1,4	14	45
2	25	8	2,4	15	69
3	75	9	4,1	16	105
4	182	10	6,9	17	161
5	383	11	11	18	244
6	745	12	18	19	367
		13	28	20	549
				21	816

Le Tableau ci-dessus est établi d'après le Tableau B de l'Annexe III

The above Table is based on Table B of Appendix III.

ANNEXE III - APPENDIX III

Tableaux des valeurs numériques pour le tracé du graphique de portée lumineuse de jour

Nota bene: Ces tableaux sont établis à la précision de la table de logarithmes à cinq décimales. Cette précision dépasse notablement celle qui peut être obtenue dans la mesure des grandeurs en cause.

Sur le graphique, la graduation des abscisses est logarithmique en intensité lumineuse et la graduation des ordonnées est logarithmique en portée lumineuse.

Le Tableau A * permet de tracer les courbes correspondant aux diverses valeurs de la visibilité météorologique. Dans l'une des colonnes 2 à 10, on obtient la courbe correspondant à une certaine valeur de la visibilité météorologique; les logarithmes (d'intensité lumineuse) indiqués dans cette colonne sont à porter en abscisses, les valeurs correspondantes de portée lumineuse indiquées dans la colonne 1 étant portées en ordonnées en échelle logarithmique. En traçant une ligne entre la série de points ainsi obtenus on obtient la courbe correspondant à la visibilité météorologique choisie.

Quand on a ainsi tracé toute la série de courbes, on peut, en utilisant le Tableau B *, établir une autre graduation de l'axe des abscisses correspondant à la portée nominale de jour. Les graduations correspondant à chaque valeur de portée nominale de jour indiquée dans la colonne 1 sont à porter sur l'echelle des abscisses, à l'endroit correspondant à la valeur donnée dans la colonne 3.

L'échelle auxiliaire des luminances de ciel est tracée selon les données du tableau C * où sont portées les corrections à affecter aux abscisses pour tenir compte de la différence entre la luminance de ciel considérée et la luminance de ciel de référence.

* Voir pages suivantes.

Tables of numerical values to be used in drawing the graph of luminous daytime range

N.B.: These tables are drawn up to the accuracy given by the five-figure logarithm tables. This accuracy considerably exceeds that which can be obtained in measurements of the quantities concerned.

On the graph, the graduation of the axis of abscissae is logarithmic in luminous intensity and the graduation of the axis of ordinates is logarithmic in luminous range.

Table A * is used to permit the drawing of the curves for the various values of meteorological visibility. The curve corresponding to any selected value of meteorological visibility is obtained from one of the columns 2 to 10; the tabulated logarithms (of luminous intensity) given in the column are to be entered as abscissae, with the corresponding values of luminous range, from column 1, entered on a logarithmic scale as ordinates. The set of points thus obtained is joined to give the curve for the selected value of meteorological visibility.

When the complete set of curves has been drawn, the axis of abscissae may be re-graduated in terms of nominal daytime range by the use of Table B *. The graduation for each value of nominal daytime range given in column 1 must be marked on the scale of the logarithm (of luminous intensity) at a position given by the corresponding value in column 3.

The auxiliary scale of sky luminances has been drawn according to the data given in Table C *, which gives the corrections to be made to the values of abscissae to take account of the difference between the actual sky luminance under consideration and the reference value on the sky luminance.

* See next pages.

TABLEAU A - TABLE A

Courbes de la portée lumineuse de jour pour diverses visibilités météorologiques

Logarithmes décimaux de l'intensité lumineuse en candelas en fonction de la portée lumineuse de jour en milles marins pour les valeurs de la visibilité météorologique figurant au Code 4300 de l'Organisation Météorologique Mondiale.

Curves of daytime luminous range for various values of the meteorological visibility

Logarithms to base 10 of the luminous intensity in candelas as a function of the daytime luminous range in sea miles for the values of the meteorological visibility appearing in Code 4300 of the World Meteorological Organisation.

Portée lumineuse de jour (en milles marins) / Daytime luminous range (in sea miles)	Visibilité météorologique – Meteorological visibility								
	Infinie Infinite	50 km	20 km	10 km	4 km	2 km	1 km	500 m	200 m
1	2	3	4	5	6	7	8	9	10
0,5	2,93322	2,95732	2,99346	3,05370	3,23441	3,53560	4,13798	5,34273	8,95699
0,6	3,09158	3,12050	3,16387	3,23615	3,45301	3,81444	4,53729	5,98299	—
0,8	3,34146	3,38001	3,43784	3,53422	3,82336	4,30526	5,26907	7,19667	—
1	3,53528	3,58347	3,65576	3,77623	4,13766	4,74004	5,94479	8,35430	—
1,5	3,88746	3,95975	4,06818	4,24889	4,79103	5,69459	7,50173	—	—
2	4,13734	4,23372	4,37829	4,61924	5,34210	6,54685	8,95636	—	—
3	4,48952	4,63409	4,85095	5,21238	6,29665	8,10379	—	—	—
4	4,73940	4,93216	5,22130	5,70320	7,14891	—	—	—	—
5	4,93311	5,17417	5,53560	6,13798	7,94511	—	—	—	—
6	5,09158	5,38072	5,81444	6,53729	8,70585	—	—	—	—
8	5,34146	5,72698	6,30256	7,26907	—	—	—	—	—
10	5,53528	6,01718	6,74004	7,94479	—	—	—	—	—
15	5,88746	6,61032	7,69459	—	—	—	—	—	—
20	6,13734	7,10114	8,54685	—	—	—	—	—	—
30	6,48952	7,93523	—	—	—	—	—	—	—
40	6,73940	8,66701	—	—	—	—	—	—	—
50	6,93322	—	—	—	—	—	—	—	—

TABLEAU B - TABLE B

Graduation des abcisses – Graduation of the axis of abscissae

Portée nominale de jour (en milles marins) Nominal daytime range (in sea miles) 1	Intensité lumineuse (en candelas) Luminous intensity (in candelas) 2	Log. décimal de l'intensité lumineuse (en candelas) Log. to base 10 of the luminous intensity (in candelas) 3	Portée nominale de jour (en milles marins) Nominal daytime range (in sea miles) 1	Intensité lumineuse (en candelas) Luminous intensity (in candelas) 2	Log. décimal de l'intensité lumineuse (en candelas) Log. to base 10 of the luminous intensity (in candelas) 3
0,5	996,03	2,99827	10	6 859,8 10^3	6,83631
1	4 627,9	3,66538	11	11 200 10^3	7,04920
1,5	12 095	4,08262	12	17 984 10^3	7,25488
2	24 977	4,39755	13	28 478 10^3	7,45451
2,5	45 334	4,65642	14	44 564 10^3	7,64898
3	75 829	4,87983	15	69 025 10^3	7,83901
3,5	119,89 10^3	5,07878	16	105,97 10^6	8,02517
4	181,89 10^3	5,25981	17	161,41 10^6	8,20793
4,5	267,41 10^3	5,42717	18	244,16 10^6	8,38768
5	383,47 10^3	5,58374	19	367,07 10^6	8,56475
6	745,08 10^3	5,87220	20	548,78 10^6	8,73940
7	1 368,4 10^3	6,13620	21	816,36 10^6	8,91188
8	2 411,5 10^3	6,38229	22	1 208,9 10^6	9,08239
9	4 118,1 10^3	6,61469			

TABLEAU C - TABLE C

Graduation de l'échelle auxiliaire des luminances de ciel
Graduation of the auxiliary scale of sky luminance

Luminance de ciel en cd/m² Sky luminance in cd/m²	Ecart à partir de la graduation de référence Distance from the reference graduation (10 000 cd/m²)
50 000	– 0,69146
20 000	– 0,29706
10 000	0,00000
5 000	0,29545
2 000	0,68242
1 000	0,97125
500	1,25531
200	1,62054
100	1,88612

L'unité d'écart à la graduation de référence est à prendre égale à celle adoptée pour le logarithme décimal de l'intensité lumineuse (en candelas) sur l'échelle des abscisses telle qu'elle est tracée d'après les indications du Tableau B. *Exemple:* Si l'unité de longueur choisie pour tracer l'échelle des abscisses est de 40 mm par unité logarithmique, le point 5 000 sur l'échelle auxiliaire des luminances sera placé à la distance:

$$40 \times 0{,}29545 \simeq 12 \text{ mm de la graduation de référence } 10\,000.$$

The unit of separation from the reference graduation is to be taken equal to that adopted for the logarithm to base 10 of luminous intensity (in candelas) on the scale of abscissae as drawn from the values given in Table B. Example: If the [illegible]

ANNEXE IV - APPENDIX IV

Table pour la détermination de la portée nominale de jour arrondie au mille marin le plus proche

Table to be used to determine the nominal daytime range rounded off to the nearest sea mile

Intensité lumineuse (supérieure à) *Luminous intensity (more than)*	Portée nominale (arrondie) *Nominal range (rounded off)*	Intensité lumineuse (supérieure à) *Luminous intensity (more than)*	Portée nominale (arrondie) *Nominal range (rounded off)*
candelas *(cd))*	milles marins *sea miles*	candelas *(cd)*	milles marins *sea miles*
1 10^3	1	14,2 10^6	12
12 10^3	2	22,7 10^6	13
45 10^3	3	35,7 10^6	14
120 10^3	4	55,5 10^6	15
267 10^3	5	85,6 10^6	16
539 10^3	6	131 10^6	17
1,02 10^6	7	199 10^6	18
1,82 10^6	8	300 10^6	19
3,16 10^6	9	449 10^6	20
5,33 10^6	10	670 10^6	21
8,79 10^6	11	994 10^6	22