

Report No. CG-D-18-92

AD-A257 030



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WATERWAY DESIGN MANUAL

M.W. Smith

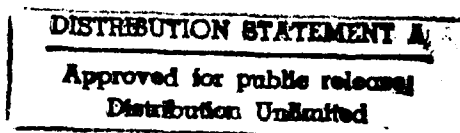
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Research and Development Center
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Groton, Connecticut 06340-6096



FINAL REPORT
September 1992

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Prepared for:

U.S. Department Of Transportation
United States Coast Guard
Office of Engineering, Logistics, and Development
Washington, DC 20593-0001

408231
92-28176
1082

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Technical Report Documentation Page

1. Report No. CG-D-18-92		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle WATERWAY DESIGN MANUAL				5. Report Date September 1992	
				6. Performing Organization Code	
				8. Performing Organization Report No. R&DC 01/92	
7. Author(s) M.W. Smith				10. Work Unit No. (TRAIS)	
9. Performing Organization Name and Address U.S. Coast Guard Research and Development Center 1082 Shennecossett Road Groton, Connecticut 06340-6096				11. Contract or Grant No.	
				13. Type of Report and Period Covered Final Report	
12. Sponsoring Agency Name and Address Department of Transportation U.S. Coast Guard Office of Engineering, Logistics, and Development Washington, D.C. 20593-0001				14. Sponsoring Agency Code	
15. Supplementary Notes This work was performed as part of Project 2703, Waterway Performance, Design, and Evaluation. The CG R&D Center contact is Dr. Myriam W. Smith (203) 441-2844 or Dr. Marc B. Mandler (203) 441-2615.					
16. Abstract This manual supplements the short range aid (SRA) system design guidelines presented in Chapter 4 of the Aids to Navigation Manual - Administration (COMDTINST M16500.7) and provides an additional tool for the Waterway Analysis and Management System (WAMS). The software, Automated Relative Risk Factor (ARRF) Computation Program, Release 2.1B, is available upon request from Commandant (G-NSR-1), U.S. Coast Guard Headquarters, Washington, D.C. 20593. The manual and the software guide the user through an evaluation process for a subject waterway. The general approach is, first, to select a "design vessel" to represent the traffic in a waterway and to divide the waterway into "regions" that will enclose the distance needed by this vessel to perform each of the maneuvers that comprise a transit. Conditions of the transit, including the configurations of the waterway, the SRAs, and the environmental conditions, are specified as inputs to the program. Based on the input, the program provides a "relative risk factor" (RRF) for each region of the waterway. These values can be used to compare risk in regions along a waterway, or to compare risk under alternative SRA systems or under alternative conditions.					
17. Key Words waterway system; short range aid system; aids to navigation system; restricted waterway; relative risk factor; risk assessment; risk management			18. Distribution Statement Document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161		
19. Security Classif. (of this report) UNCLASSIFIED		20. SECURITY CLASSIF. (of this page) UNCLASSIFIED		21. No. of Pages	
				22. Price	

METRIC CONVERSION FACTORS

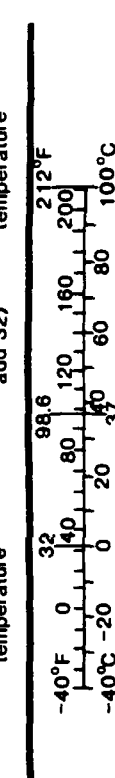
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	* 2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
AREA				
in ²	square inches	6.5	square centimeters	cm ²
ft ²	square feet	0.09	square meters	m ²
yd ²	square yards	0.8	square meters	m ²
mi ²	square miles	2.6	square kilometers	km ²
	acres	0.4	hectares	ha
MASS (WEIGHT)				
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
VOLUME				
tsp	teaspoons	5	milliliters	ml
tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft ³	cubic feet	0.03	cubic meters	m ³
yd ³	cubic yards	0.76	cubic meters	m ³
TEMPERATURE (EXACT)				
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

* 1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures. Price \$2.25. SD Catalog No. C13.10.286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
AREA				
cm ²	square centimeters	0.16	square inches	in ²
m ²	square meters	1.2	square yards	yd ²
km ²	square kilometers	0.4	square miles	mi ²
ha	hectares (10,000 m ²)	2.5	acres	
MASS (WEIGHT)				
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
VOLUME				
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	0.125	cups	c
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m ³	cubic meters	35	cubic feet	ft ³
m ³	cubic meters	1.3	cubic yards	yd ³
TEMPERATURE (EXACT)				
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



ACKNOWLEDGMENTS

This Manual is the result of years of work by many people from many organizations. The author is grateful to all of them, but in deference to the reader will name only a few of the most involved or the most recent:

- ♦ from the U.S. Coast Guard: formerly of the Office of Navigation, CDR H.H. Sharpe; from the earlier Office of Research and Development, MR. W.R. Ridley; from the National Aids to Navigation School in Yorktown, Virginia, LT S. Kinner, LCDR E. Merkle, and LT M. Simmons; from the Research and Development Center in Groton, Connecticut, Dr. M.B. Mandler and LCDR M. Lytle;
- ♦ commercial pilots' associations: most especially, the Northeast Marine Pilots Incorporated of Newport, Rhode Island; but also the Sandy Hook Pilots Association, the Delaware Pilots Association, the Association of Maryland Pilots, the Lake Pilots Association, and the Virginia Pilots Association;
- ♦ simulator facilities: the Computer Aided Operations Research Facility (CAORF) in Kings Point, New York; the prototype U.S. Coast Guard/Ship Analytics Simulator; the Maritime Training and Research Center (MTRC) in Toledo, Ohio; and, most recently, the Ship Control and Navigation Training System (SCANTS) at the U.S. Coast Guard Academy in New London, Connecticut;
- ♦ individuals: most especially, W.R. Bertsche, then with Ship Analytics, Incorporated of North Stonington, Connecticut, who wrote the first draft of the manual in 1982, boldly going where no manual had gone before; J. Mazurkiewicz, who finally quantified the ship effect; P.J. Ryan and D.G. Smith, now with MicroSystems Integration Incorporated, of Stonington, Connecticut, who took the software through two iterations; and many other individuals at Ship Analytics who worked on every part of a 13 year project, from concepts to collating.

I hope they would all approve of the final result.

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1.0 INTRODUCTION

1.1 PURPOSE

The Waterway Design Manual supplements the short range aid (SRA) system design guidelines presented in Chapter 4 of the Aid to Navigation Manual - Administration (United States Coast Guard, COMDTINST M16500.7) and provides an additional tool for the Waterway Analysis and Management System (WAMS). This Waterway Design Manual differs from other tools in that it focuses on the provision of SRA systems to the relatively high risk and high cost operations of deep draft vessels transiting narrow channels. For this type of operation, it provides a quantitative measure of quality, or risk, for candidate systems. The Design Manual is accompanied by the Automated Relative Risk Factor (ARRF) Computation Program, Version 2. 1B, custom software for the United States Coast Guard (USCG) Standard Work Station. The user's manual for the Program is embedded in this Design Manual. Together, the Manual and the Program provide a "job aid" for the design and evaluation process. (Note that they replace an earlier Manual (Smith et al., 1985) and earlier software, Version 1.1. The earlier Manual and software produced relatively conservative risk estimates. The new versions are based on new, highly-refined performance data and produce lower, more realistic, risk estimates. For this reason, results with the two sets of materials are not compatible and should not be mixed or compared.)

The Design Manual guides the user through the evaluation process for the subject waterway. The general approach is, first, to select a "design vessel" to represent the traffic in a waterway and to divide the waterway into "regions" that will enclose the distance needed by this vessel to perform each of the maneuvers that comprise a transit. Conditions of the transit are then specified as inputs to the Program. They include characteristics of the design vessel, width and turn configurations of the waterway, environmental conditions, and SRA configurations (existing or considered). Based on this input, the Program provides a "relative risk factor" (RRF) for each region of the waterway. RRF values can be used to compare the risk in regions along a waterway, or to compare risk under alternative SRA systems or alternative conditions.

The design and evaluation process is a tool for the assessment of risk; the user's objective is the management of risk. Management techniques, that are appropriate for the use of the relative risk factor, are suggested and discussed. Briefly, the techniques and examples of their use are as follows:

1. Designing for comparable risk at least cost. The user selects an existing set of conditions with a known record of acceptance and safety and uses it as a baseline to which to compare

alternative SRA systems or operational practices. The assumption is that an alternative that achieves the same level of RRFs as the existing system has the same expectations for safety. This approach is recommended as the primary one because of its potential for the control of costs. Examples of management objectives that can be served by this technique include the following:

- ♦ to seek uniform risk along a waterway
- ♦ to prioritize work along a waterway
- ♦ to justify reductions in service along a waterway
- ♦ to evaluate design proposals or requests
- ♦ to respond to changing needs

2. Designing for minimum risk. The user evaluates alternative SRA systems and operation practices for a waterway to identify the lowest RRFs possible in that waterway. The assumption is that the alternative that achieves the lowest values provides the maximum safety. This alternative will probably prove the most costly and should be implemented only when circumstances justify additional cost. Examples of applications of this technique include:

- ♦ to support critical military use
- ♦ to ensure safety for sensitive cargoes
- ♦ to establish the lower limit of risk for the waterway

The Design Manual provides a structured and systematic process for the design and evaluation of SRA systems and an objective assessment of risk, but the user's judgment is required at every step. To inform this judgment, a discussion of the background of the process and the nature of the RRF measure follows.

1.2 BACKGROUND AND INTERPRETATION

1.2.1 Simulator Experiments

Real-time man-in-the-loop simulation was used to provide controlled and replicated performance data not obtainable at sea. Performance data are "generic," that is, not specific to any waterway but applicable to a wide variety of related waterways and conditions. The subject of the experiments was the "system" formed by the waterway, the ship, the shiphandler, the environment, and the SRA configuration. Each component could be varied and investigated in turn. Repeated runs under standardized conditions were made for each variation. As an example, repeated runs with a high density of SRAs were made under the same conditions as those made with a low density of SRAs. Performance in each case provided a measure of the relative performance, or risk, to be expected with such an SRA configuration. Each component included in the experiments is described briefly below.

1. The waterway. The majority of runs were made with channels 500 feet wide. Variations in width were allowed for very large ships and to establish a general effect of channel width. Because the intention was to evaluate the information provided by the SRA system, there were no bank or sidewall effects that might provide additional information about the ship's position. Turns were 15 or 35 degrees and cutoff or not cutoff at the "corner." (Relevant waterway conditions are described where needed in Sections 4.2, 4.3 and 4.4.)

2. The ship. Sophisticated hydrodynamic models were used to represent large, commercial ships. Only the most difficult to handle types, tankers and bulk carriers, were included and these were modeled fully loaded. Ships ranged in size from 30,000 deadweight tons to 250,000 deadweight tons. (Ship characteristics are described where needed in Section 4.1.)

3. The shiphandler. The shiphandlers were commercial pilots with active state and federal licenses and recent experience with the ship and waterway dimensions they tested. Because they did not have "local knowledge" of the generic waterways, their performance was strongly dependent on the information provided by the SRA system and provides a strict measure of its quality. Other shiphandlers might not necessarily achieve the same performance for these demanding conditions. For less expert shiphandlers the calculated results may under-estimate risk.

4. The environment. Conditions incorporated in the process here include day and night and variations in wind and current. For the sake of experimental control, the greater pool of performance data were collected under simplified conditions of one-way traffic and adequate visibility. It was assumed that the best SRA systems for these conditions would also be the best for two-way traffic and reduced visibility (with radar). This assumption was tested and supported. A brief overview of the findings on reduced visibility and traffic appears in Section 5.2.4.

5. The SRA configurations. It was assumed that visual piloting is the basic technique for piloting in restricted waterways and that the primary purpose of the design process was to evaluate the service provided for this basic technique. To this end, the majority of the simulation was designed to provide performance data on day and nighttime SRAs, positioned at their charted position at the channel edge, and for visual ranges. Visibility was adequate for the aids being evaluated. In order to ensure that performance data were a measure of the effectiveness of the SRAs of interest, no land or other objects were available to provide additional positioning information. Radar was not available unless it was the subject of the investigation. Additional findings on floating SRAs, landmass, and radar and electronic navigational displays are discussed briefly in Section

5.2.4. (SRA configurations are described in Section 4.3, 4.4, and 4.5 where needed.)

1.2.2 Performance Measures

During the experiments the primary measure was of the cross-channel position of ship tracks as pilots made repeated runs under the same set of conditions. The assumption was that good performance, or low risk, would be achieved when the pilots were certain of their position and had good control of the ship. This low risk would be characterized by a precision of tracks: that is, the mean of the distribution would be close to the centerline, the standard deviation would be small, and there would be a good distance to the channel edge from both sides of the distribution. Poorer performance, as when the pilots had less certainty of their position or more difficulty controlling the ship, would be characterized by a greater mean distance from the centerline or a larger standard deviation of the distribution. Either way in which poorer performance was expressed, less distance from the channel edge would be available to one or the other side. This smaller distance would mean greater "risk" of grounding.

These measurement assumptions are the basis of an index called the Relative Risk Factor (RRF). The general concept of the RRF is illustrated in Figure 1.2.2. For a specified set of conditions and for a specified waterway region, the mean crosstrack position of the ship's center of gravity during multiple transits by multiple pilots is selected to represent the characteristic maneuver for that region. This mean crosstrack position is adjusted, for the ship's beam and the heading relative to the channel course, to represent the distributions of the two extreme points of the ship's contour most exposed to the channel edge. A Gaussian distribution, with the observed standard deviation, is assumed around each of the extreme means. The probabilities of grounding to port (P_p) and to starboard (P_s) are calculated. The total probability of grounding on either channel edge is the RRF for that region of the channel. The derivation of this measure is discussed in earlier reports (Smith et al, 1985 and Bertsche, Smith, Marino, and Cooper, 1982).

The values of the RRF will vary with a number of parameters:

- ♦ the experimentally derived cross-channel distribution of tracks for conditions. This parameter is selected by the Program based on conditions specified by the user. Specification of conditions is described in Section 4.
- ♦ the length and beam of the design vessel. These parameters must be input by the user. Design Vessel parameters are discussed in Section 4.1.
- ♦ the design vessel's heading relative to the channel direction

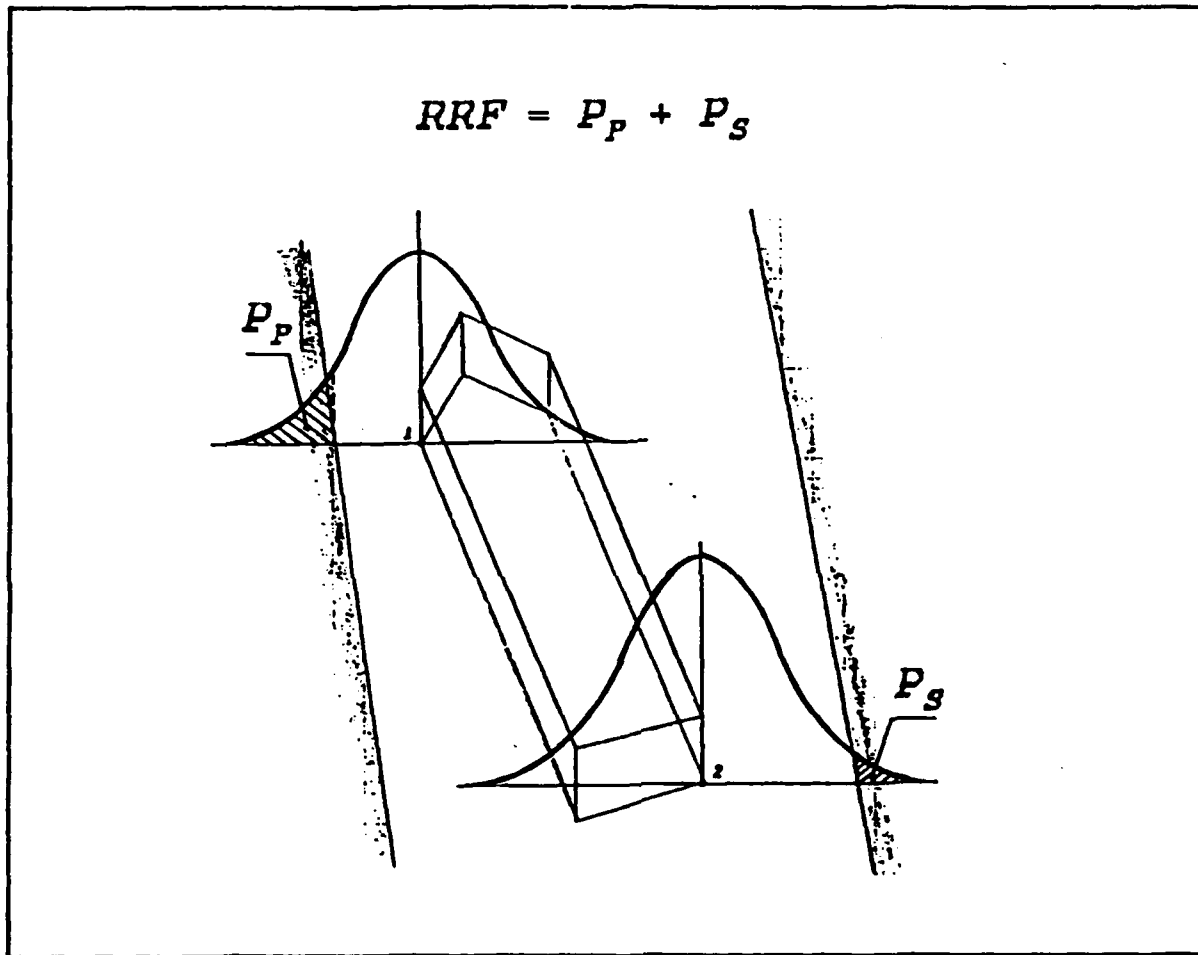


FIGURE 1.2.2. THE GENERAL CONCEPT OF THE RELATIVE RISK FACTOR

as required by maneuver: turn, recovery, or trackkeeping. The maneuver is specified by the user as directed in Sections 4.2, 4.3, and 4.4. The Program will select the appropriate heading during calculations.

- ♦ the design vessel's heading relative to the channel direction as required by the wind and current conditions. The user will specify the wind and current effect as directed in Sections 4.2, 4.3, and 4.4. The resulting heading will be calculated by the Program from user input.

1.2.3 Application and Interpretation of the Relative Risk Factor (RRF)

The methodology described above suggests a number of implications for the application and interpretation of RRF values:

- ♦ Only conditions that were evaluated during the experiments, or in subsequent data analyses, can be appropriately evaluated. For example, the performance of highly-maneuverable vessels in very narrow channels cannot be addressed.

- ♦ The RRF is a relative measure, assumed to be proportional to an actual or realistic probability of grounding for a set of conditions, rather than being itself an absolute probability of grounding. As such, it is most appropriate for comparisons among conditions evaluated by the same process, comparisons that will be suggested in the following sections. It should not be used for management techniques that require an absolute measure of performance.

- ♦ The RRF is a "conservative" measure and will yield higher estimates of the risks of grounding in a waterway region than can be defended as realistic. As an example, an RRF value of 0.3 is not uncommon, but cannot be interpreted as a realistic expectation that 3 out of 10 transits will ground in the region. Instead, conservatism provides a margin for conditions not included in the consideration or not foreseen. Section 4 contains suggestions for the manipulation of the degree of conservatism by the user.

- ♦ While the risk of "grounding" is emphasized here, it is assumed that this risk is related to those of collisions and rammings. Conditions that allow the pilot to make accurate and timely estimates of his ship's position, velocity, and acceleration should contribute generally to the safety of a waterway transit.

1.3 OVERVIEW OF THIS MANUAL AND THE EVALUATION PROCESS

An annotated table of contents for rest of report is presented below.

2.0 INFORMATION COLLECTION AND PREPARATION contains a brief overview of a recommended information collection. Generally, this is the similar to that suggested in the Aids to Navigation Manual - Administration as a part of the WAMS process. Familiarity with the contents of this Design Manual early in the WAMS process will ensure that all needed information is available. This section also contains expanded directions for dividing the chart of the waterway into "regions."

3.0 USER'S MANUAL FOR THE AUTOMATED RELATIVE RISK FACTOR (ARRF) COMPUTATION PROGRAM is the only user's manual for the program. It assumes the user is familiar with the USCG Standard Work Station.

4.0 "JOB AID" FOR ENTERING DATA provides guidance for the specification of the conditions of interest: design vessel characteristics, channel width and turn configurations, existing and potential SRA arrangements, environment, etc. A major feature of the program is a series of data input screens, requesting this information. The Program itself repeats critical portions of this guidance in the form of help screens. The accuracy and applicability of the output is dependent on the accuracy of the input.

5.0 INTERPRETATION AND APPLICATION OF THE RESULTS contains, first, a discussion of the report printed by the program. More importantly, it contains a discussion of risk management procedures appropriately supported by the program.

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2.0 INFORMATION COLLECTION AND PREPARATION

2.1 FAMILIARIZATION WITH THE WATERWAY

The Aids to Navigation Manual - Administration in Chapter Four and Enclosure 5 presents guidelines for the collection of information needed for a WAMS analysis. An obvious first source for familiarity with the waterway is a review of published material, including NOAA charts, Coastal Pilot, Light Lists, current tables, etc. Survey drawings from the U.S. Army Corps of Engineers will be valuable. Ultimately, the USCG system designer must ride with the mariner to observe the waterway and to share the mariner's familiarity with it. For the purposes of this analysis, this should be done with the commercial pilot group(s) and on the design vessel. Because of the emphasis here on visual piloting, this should be done when conditions are appropriate. Information that will be needed or useful for the most effective use of the design and evaluation process is discussed briefly below.

2.1.1 The Physical Waterway and Its Environment

The physical dimensions of the channel are critical. Of interest is the depth and width of safe water and the configuration of the turns for the design vessel. Such conditions as bottom composition, strong bank effects, shoaling, and large watch circles on SRAs may influence the amount of water that is actually available. The system designer may want to consider whether to adjust channel width from what is indicated on the chart, or to increase the degree of conservatism of risk estimates. This latter possibility is discussed in Section 4.

Environmental factors are important. Current, wind, and fog are obvious factors. The Program requires the crosstrack component of the current in each region of the waterway. Unusual current, wind, or fog that affect the difficulty of shiphandling might be a reason to increase the conservatism of risk assessments for a particular region--or for an entire waterway. The design project has never considered the effects of ice, but increasing the conservatism of risk estimates would be the most appropriate way available to include it.

2.1.2 A Pilot's Eye View

Riding with the pilot will provide a variety of information. The pilot, from experience and practice may be able to fill in, or elaborate on, the characteristics of the waterway, the environment, and the design vessel. Observation of, and discussion with, the pilot will provide an understanding of how characteristic maneuvers for each region are actually performed and how the SRAs are actually used. The ride will provide

insight on the usefulness of landmass or targets of opportunity in visual piloting. It will provide information on such the local practices as transit speed, preferred regions for meeting traffic, and where large ships slow for tugs. Such factors may suggest a need for greater, or lesser, conservatism in assessments of risk.

A more subtle benefit in riding with the pilot is possible. The purpose of this design and evaluation process is the assessment of risk for the waterway. This structured and systematic approach, that provides an objective and quantitative measure, was developed to replace unsystematic, subjective approaches. However, a major part of the pilot's task and skill involves the expert subjective assessment of risk and the adjustment to it. Taken with caution, the pilot's assessment of the risk of conditions may contribute to a decision as to whether conservatism is needed and to the interpretation of the measured levels of risk.

2.2 SELECTION OF THE DESIGN VESSEL

The simplest and most straight-forward approach is to select as design vessel the largest, least maneuverable, or highest risk ship that transits a waterway. If this is a tanker or bulk carrier, risk assessment will be "conservative" in that the RRF values will be higher than realistic probabilities of grounding for the conditions. (The reasons for this are discussed in Section 1.2.) For more maneuverable ships, such as passenger or military ships, the matter of conservatism is more complex. If the user inputs only the physical dimensions of the ship, the Program will assume the controllability characteristics of a tanker/bulker with those dimensions, and will provide very conservative estimates of risk. If the user can provide the actual controllability characteristics of the more maneuverable ship, the estimates will be more realistic. For ships that are strongly influenced by wind, such as ballasted tankers/bulkers, container ships loaded above the deck, liquefied natural gas vessels, etc., current effects can, with caution, be substituted for wind effects. The process cannot be considered appropriate for such configurations as tug and tow, integrated tug and barge, aircraft carriers, or submarines.

If the largest ship to transit a waterway does so only infrequently, it may be more appropriate to select a more frequent ship as the primary design vessel. When the analysis is completed for the smaller ship, risk for the larger one can be addressed separately. To do this, copy and re-name the first waterway file as instructed in Section 3.3.2.3 and replace the design vessel. Risk management techniques discussed in Section 5.2 can then be used to design a system for the larger ship that will make its risk comparable to that for the smaller one or that will, at least, minimize its risk.

The specific information that is required about the design vessel is described in Section 4.1.

2.3 DIVISION OF THE WATERWAY INTO REGIONS

The design process here treats the waterway as a series of "regions" based on the maneuver required in each: turn, recovery, or trackkeeping. The type of maneuver in a region determines the type of information that must be provided to the pilot by the aid system and the performance or risk that can be expected. The following subsection directs the division of the waterway, on the chart, into regions. Figure 2.3 illustrates the concept. Two approaches are possible: either to outline all the turns first or to start at the entrance and progress up the waterway.

2.3.1 Turn Region

The turn is the most difficult maneuver, is most dependent on the information available, and will generally show the highest RRF values. Navigating the ship safely around the turn can be described as a complex sequence of three limited maneuvers. First, the preparation for the turn may involve a crosstrack movement away from the direction of the turn and small changes in heading and rudder toward the turn. Second, the major change in course is accomplished by a relatively large and sustained rudder deflection in the new direction. The third step occurs as the ship passes the channel apex, sliding toward the outside of the next leg, and the rudder is reversed to counteract the turn motion. The turn region as defined here is intended to enclose this entire sequence. The guidelines presented in Section 2.4 for the marking of the turn region assume that the pilot must make accurate and timely estimates of the ship's position, velocity, and acceleration for each step.

A conservative distance, DT, in each direction from the turn apex for the turn region, T, is presented below as a function of design vessel LENGTH.

Vessel LENGTH:		Distance, DT:			
<u>feet</u>	<u>meters</u>	<u>nautical miles</u>	<u>yards</u>	<u>meters</u>	
to 600	183	0.42	850	777	
to 700	213	0.45	911	833	
to 800	244	0.47	952	870	
to 900	274	0.50	1012	925	
to 1000	305	0.52	1053	963	
to 1100	335	0.54	1094	1000	

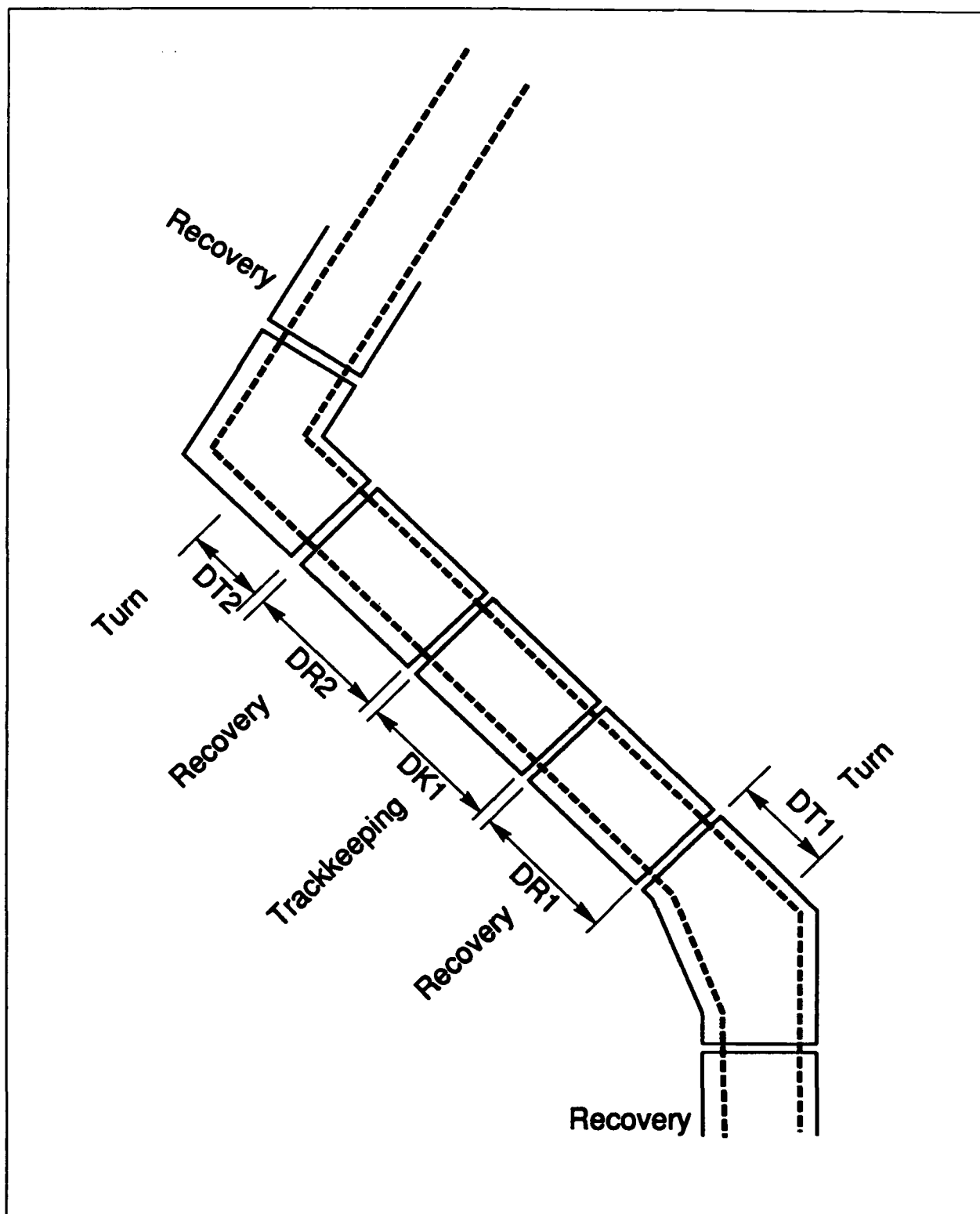


Figure 2.3. Division of the Waterway into Regions for Required Maneuvers

Figure 2.3.1 illustrates the measurement of this distance for each type of turn considered:

- ♦ a noncutoff turn is one that allows only the width of the straight segments
- ♦ a cutoff turn is one that is widened, generally to the inside
- ♦ a bend is a gradual change from one course to the next

Linked, S-shaped, or reversing turns may be treated as successive turn regions without other types of regions intervening between them. If an appropriate treatment is not apparent, reports from the pilots as to how they make a turn may be helpful.

2.3.2 Recovery Region

The recovery region encompasses the pilot's efforts to find a new track in the new channel leg, to maneuver the ship to it, and to achieve a heading and rudder angle that will hold that track in the presence of any current. For a two-way channel, there are recovery regions in both directions from a turn. The entrance to the waterway from the sea may also be considered a recovery region.

A conservative distance, DR, for recovery region, R, in each direction from the turn apex is presented below as a function of design vessel BEAM. Select the appropriate distance and subtract the turn region distance, DT, from it to find DR, the distance illustrated in Figure 2.3.

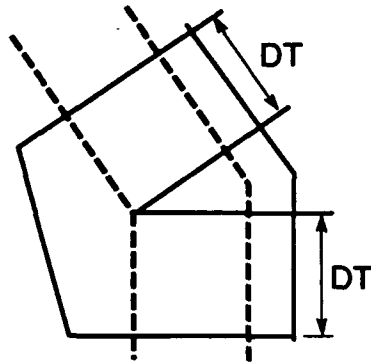
Vessel BEAM:		Recovery:			
<u>feet</u>	<u>meters</u>	<u>nautical miles</u>	<u>yards</u>	<u>meters</u>	
to 80	24	1.4	2835	2592	
to 100	30	1.75	3544	3241	
to 120	37	1.95	3949	3611	
to 140	43	2.15	4354	3981	
to 160	49	2.35	4759	4352	
to 180	55	2.5	5063	4630	

2.3.3 Trackkeeping Region

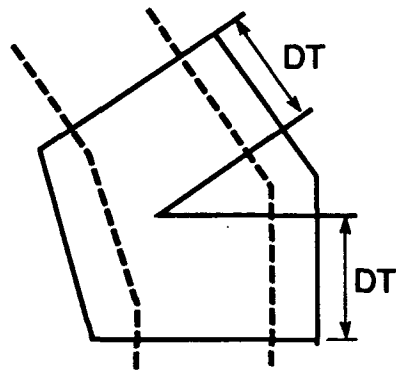
The trackkeeping region encloses the region of the straight leg where the ship has arrived at the track and heading intended by the pilot, and only minor adjustment of rudder and heading are required. Reaches with severe, variable currents or frequent on-coming traffic may better be considered "recovery" for their length.

The distance, DK, for the trackkeeping region, K, is what remains in the straight leg. For large ships in short reaches, there may be no trackkeeping regions.

Noncutoff



Cutoff



Bend

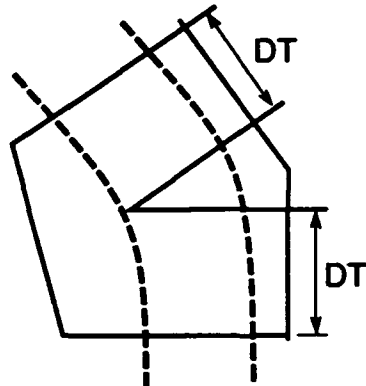


Figure 2.3.1 Measurement of the Turn Region Distance

2.4 GUIDELINES FOR SHORT-RANGE AIDS (SRA) SYSTEMS

The following subsections provide a general overview of suggested possibilities for marking the regions. These possibilities are considered very specifically in Section 4 where they are accompanied by diagrams.

2.4.1 Marking for the Turn Regions

This highest risk region should be given the first consideration in marking the waterway. SRA possibilities are different for noncutoff and cutoff turns. These dredging configurations are illustrated in Figure 2.3.1 above. The marking possibilities discussed below are illustrated in Figure 4.2 in Section 4.2 where they are needed to guide data input.

For noncutoff turns marking arrangements Types 1, 2, and 3 are suggested. Type 1 offers an SRA only at the most critical inside apex of the turn, marking the inside limit of safe water for the most severe part of the turn. The Type 2 arrangement provides a second SRA at the outside apex as well. This second SRA improves the pilot's judgment of crosstrack position as the ship approaches the apex and marks the extend of safe water to the outside, where the ship is not likely to use it. Neither arrangement provides any certainty of alongtrack position before the turn apex and, therefore, tempts the pilot to wait until the ship is close to the apex and the relative certainty of the SRAs there before beginning the turn. For a large ship this may mean a less than optimal turn. Type 3 provides an SRA before the apex against which to judge alongtrack position and select the point at which to begin the turn, one at the apex, and one at the pullout, where the pilot reverses the rudder. The SRA there gives the pilot an object against which to judge the swing of the ship. Note that the setup SRA in one direction is the pullout in the other. This arrangement does not allow for the best judgment of crosstrack position in the turn, but crosstrack position is critical only for meeting traffic and large ships will not meet traffic in a turn.

For a cutoff turn a Type 1 arrangement offers one SRA along the inside diagonal. If that SRA is directly on the diagonal the pilot will not be able to accurately judge the outline of the safe water. If it is to the inside of the diagonal, the extra width cannot be used and the turn functions as a noncutoff turn. A second SRA to the outside apex offers some greater certainty of crosstrack position, but this has not proven to be important during the turn maneuver and the arrangement should be considered a variation on a Type 1 arrangement. A Type 2 arrangement offers two SRAs marking the two extremes of the diagonal, allowing the

pilot to make the best use of the available safe water to make a more gradual, longer radius turn. A Type 3 arrangement offers a third SRA at the outside apex. For most turns this will be of value primarily to indicate crosstrack position in the approaching or departing legs, but will provide little during the actual turn maneuver.

A very long and wide cutoff turn that is marked with a Type 3 arrangement may not be treated by the pilots as a single long-radius turn. It may be treated as two separate low-angle turns, with or without a recovery region between them. If it is large enough, it may be a preferred meeting spot. The pilot's treatment of a region should be the determining factor in how the regions are divided and marked.

Ranges alone are not recommended as a marking for the turn region. They are designed and are effective for providing crosstrack information in the channel, but alongtrack information is essential in initiating and checking the rudder actions needed in the turn. Risk estimates generated by the Program for the turn region will reflect the prediction of relatively poor performance. When ranges are present, pilots watch the ship's rate in closing on the range in the next leg for the best estimate of its alongtrack distance so if a range is to be used in this way, it is critical that it is highly sensitive. Aft ranges are assumed to be less effective generally and therefore even less effective as turn marking. The discussion of ranges in Section 4.2 suggests a procedure for increasing the conservatism of risk estimates for aft ranges.

How conservatively or heavily a turn needs to be marked depends on a number of factors and their interrelation. Factors to consider include: the angle of the turn, the channel width, the dredging configuration, the severity of currents, the size of the design vessel (or other representative traffic), the frequency of reduced visibility, the percentage of nighttime transits (which are more dependent on the SRAs), and the frequency of meeting traffic (in the reaches before or after the turn).

2.4.2 Marking for the Recovery Regions

Performance in the recovery region is relatively less dependent on SRAs than it is in the turn. Possible arrangements are suggested below. These arrangements are illustrated in Figure 4.4 in Section 4.4 where they are needed to guide data input.

The highest performing, lowest risk arrangement is gated, where SRAs are opposite each other on a line perpendicular to the channel axis. This arrangement enables the pilot to accurately find both the edge of the channel, which is marked, and the centerline, which is found by "splitting the gates." The effectiveness of this arrangement is relatively resistant to increases in spacing. This arrangement is the most frequent for

large ships in large channels and is the most recommended arrangement of sidemarks.

Another possibility is a staggered arrangement, where the SRAs are arranged on alternating sides of the channel. Performance with irregular arrangements will be similar. Staggered SRAs offer the potential of requiring fewer SRAs per nautical mile than does gated but performance deteriorates more readily with increased spacing. Short spaced staggered arrangements allow the pilot to treat them as if they were gated. But the longer the spacing, the more important the pilot finds the certainty of the position of the one SRA ahead and the greater is the tendency to "buoy hop." The pilot adjusts the heading to pass inside the SRA ahead; then, as the ship comes close to it, the heading is changed to pass inside the next one on the opposite side. Frequent changes in heading and track mean that performance is sensitive to any unfavorable circumstances. This arrangement is probably most appropriate for small ships in reduced visibility without radar, a situation outside the scope of this design process.

A third possibility is a one-sided arrangement, where SRAs are arranged only on one side of the channel. This obviously offers the potential for fewer SRAs per nautical mile. However, the pilot's ability to judge the ship's "distance off" a single SRA nearby or the channel edge marked by SRAs ahead is relatively poor. Performance will be very sensitive to current, wind, and traffic. Channels marked in this way are generally short and wide. It may be appropriate for short reaches with the turn SRAs visible ahead.

Ranges provide a high performing possibility for recovery. A range marks the centerline and, therefore, encourages prompt and accurate achievement of the centerline in the new reach. For a large ship that needs to find and maintain the center of the channel, ranges are ideal. However, ranges can only be relied upon when the visibility is adequate. Because they do not mark the channel edge, they may not provide good support for meeting traffic. It is assumed that aft ranges are less effective than those ahead. The discussion of ranges in Section 4.2 suggests a procedure for increasing the conservatism of risk estimates for aft ranges.

The conservatism of marking needed in a recovery region depends on a number of factors and their inter-relationships. Consider: channel width and ship size, the length of the reaches (how much distance a large ship has in which to achieve a new track and heading before meeting traffic or setting up for a new turn) crosstrack wind and current, the frequency of reduced visibility, the percentage of nighttime transits, and the frequency of meeting traffic.

2.4.3 Marking for the Trackkeeping Regions

The possibilities for marking a trackkeeping region are the same as those described above for the recovery region. Because trackkeeping is a less demanding maneuver, less conservatism is required. Lower performing arrangements may be considered. However, consider also the factors for conservatism listed for the recovery region.

2.4.4 Marking for the Waterway as a Whole

While the emphasis here has been on examining and marking the waterway by regions, the SRA system must support a smooth transit of the waterway as a whole. The waterway should be examined with these considerations.

1. A smooth transition between regions. The transition from the turn to the recovery region is the most critical. Sparse marking in the turn may suggest that the recovery SRAs need to be closer. For a Type 1 or Type 2 turn, the first recovery SRA or gate substitutes for a pullout SRA. Because the recovery region SRA will be farther from the ship's bow when the pilot needs to judge the ship's swing, effectiveness will be reduced. For an undemanding turn, the decreased effectiveness may be sufficient. For a cutoff turn of any type, the first recovery SRAs will serve a pullout function. Since the gradual, long radius turn allowed by the cutoff is not demanding, this should be appropriate. A gate up ahead or a range provide the smoothest recoveries from a turn. If a turn marked with one, three, or five SRAs is to be followed by staggered or one-sided recovery markings, the first recovery SRA should be on the opposite side of the channel from the last turn SRA.

If a straightaway does not have a trackkeeping region, the distance from the last SRA in one turn to the first SRA in the next should be divided into equal spacings for gates (or staggered or one-sided SRAs). This division may suggest an adjustment of the SRAs in the turn. If a straightaway does have a trackkeeping region, consideration can be given to increasing the spacing or decreasing the SRA density. The longer spacing might be twice the shorter or might go to some larger division or multiple of a nautical mile.

2. Spacing. SRA spacing should be examined both within and across regions. An obvious consideration is the distribution of visibilities to be expected. The Aids to Navigation Manual - Administration, Chapter 4 presents guidelines for spacing as a function of visibility.

Another consideration is ship size. The relation between ship size and spacing is complex. On the one hand, large ships tend to

have a high height of eye that allows the pilot to see far ahead. (Table 4.2 in Section 4.2 presents representative heights of eye for large commercial ships.) In addition, the large ship has radar and sophisticated operators. These conditions suggest spacing need not be very close. On the other hand, commercial pilots tend to have a preference for visual piloting when visibility allows. The large ship needs substantial alongtrack distances for maneuvers (as in Section 2.1), suggesting a need for sufficient close aboard SRAs for timely position estimates to anticipate and control maneuvers throughout the transit.

Additional factors that increase the importance of timely and accurate estimates of crosstrack position suggest shorter spacing. Consider substantial or varying wind and current, or frequent, oncoming traffic.

3. Transits in both directions. Lastly, the waterway system should be examined to ensure that transits are supported in both directions. The need for SRAs may not be the same in both directions. Features on land may be more helpful or background lighting more distracting in one direction than the other. Bank effects may be more helpful in one direction than the other. Ranges will be less effective as rear ranges. Ships may be consistently more deeply loaded in one direction than the other. Turns may not be made the same way in both directions. If the need is the same in both directions, the service provided by the SRAs should be the same.

After this qualitative evaluation of the aid system, the Automated Relative Risk Computation Program can be used to provide a quantitative assessment of the performance or risk that can be expected from alternative possibilities. The next two sections here involve the use of this Program.

SECTION THREE

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3.0 USER'S MANUAL FOR THE AUTOMATED RELATIVE RISK FACTOR (ARRF) COMPUTATION PROGRAM

3.1 INTRODUCTION

This section is a "user's manual" for the Automated Relative Risk Factor (ARRF) Computational Program, Version 2.1B, 15 DEC, 1991. It assumes a working knowledge of the Coast Guard Standard Work Station. For information on this computer, see the Unisys Manual for the Standard Software.

Additional materials provided in this Manual about the Program include the following:

- ♦ Section 4, which provides an extended discussion of the required input data
- ♦ Appendix A, which reproduces the Help screens provided in the Program
- ♦ Appendix B, which provides a sample Waterway Report

3.1.1 Program Installation

To install the ARRF program, place the floppy disk in the disk drive and execute the software installation command appropriate to your system without parameters (for example, 'Software Installation' or 'Floppy Install'). The system can also be installed by executing the submit file 'Install.sub' on the distribution disk. Installation of the software will delete data files from previous versions of the program if it is installed in the same volume/directory. Old data should either be printed out or the old and new systems should be placed in different directories. Data from earlier versions is NOT compatible with that from the newer version, and vice versa.

The following files will be installed:

ARRF.Run: the main executable program

Fields.RRF: a data file which contains information needed for constructing forms and screens used by the program

HelpSc.RRF: Help screen data

Tables.RRF: A data file which contains the normal distribution data used in the RRF calculation.

3.1.2 Program Operation

To execute the installed program when the command prompt appears, enter 'RRF' and press [RETURN].

Alternately, if you prefer to use the RUN command:

1. When the command prompt appears, enter 'RUN' and press [RETURN]
2. For Run File Name enter 'ARRF.Run' and press [GO]

When the program is run for the first time, two additional files will be created:

WWList.RRF: a data file which contains the list of active waterways

Config.RRF: a data file which contains the current program configuration

If these files already exist from a previous version of the program, they will not be modified.

3.1.3 File Management

3.1.3.1 Active Waterway List

The file WWList.RRF lists the waterways available. Whenever a waterway is created or deleted by the Program, its file name is automatically added or removed from the list. To make a waterway file "invisible" to the Program, edit the file WWList.RRF using the standard Editor or Word Processor and the desired file name will be removed from the list. To add file names, follow the following conventions:

- ♦ All lines must end with a carriage return.
- ♦ The first line in the file must consist of the words 'Active Waterways:'.

3.1.3.2 List Files

Use the FILES command to list all files in a directory. This command is 'FILES' followed by [RETURN]. See the Unisys Manual for the file listing options.

3.1.3.3 Delete Files

Any file can be deleted separately or as part of a files list with the DELETE command: 'DELETE' followed by [RETURN].

3.1.3.4 Copy Files

Use the COPY command to copy the content of one file to another: 'COPY' followed by [RETURN]. LCOPY copies a file from one volume or directory to another more easily than COPY. See the Unisys Manual for a complete description of the copy options.

3.1.4 Error Messages

The following error messages may appear in the course of running the program:

"File TABLES.RRF does not Exist": This means that the distribution data file cannot be found by ARRF.RUN, and the program cannot continue. User should ensure that in making a copy of the ARRF.RUN, both the TABLES.RRF and FIELDS.RRF are also copied into the same directory. If they are not in the directory the RRF Computation Program cannot run.

"File Fields.RRF does not Exist": This means that the Screen/Form data file cannot be found by ARRF.RUN, and the program cannot continue. (Solution to error is same as above).

"Invalid Data Path [Vol] or Dir": This means that the Data Path specified in the program configuration file is either invalid or nonexistent, and the program cannot continue. The user should consult the Unisys Manual for assistance, and correct the configuration file by executing the RRF program again and changing the Data Path.

"A Waterway must be selected first": This means that the user is attempting to work with waterway regions without prior specification of a waterway. The user should either create a new waterway or select an existing one before continuing the current operation.

"Invalid or out-of-range number": This means that the number entered is either not acceptable as a real or integer, or it is too large for the data entry field. User should then re-enter the data.

"Invalid Data Path": This means that the path specified is not recognized by the operating system. The cause may be a syntax error such as not including the proper brackets in the path ([volume] <directory> or <directory> is correct. Also, specifying a path that does not exist (for example, specifying a volume and directory on a floppy disk when the disk has not yet been placed in the drive) will cause this error.

"Waterway list is full. Region not added": A waterway can have a maximum of thirty-five regions; the user attempted to add a thirty-sixth region and the system rejected it.

"Waterway list is full. Create denied": The user attempted to add more entries to the active waterway list than are allowed. The file of active waterways (WWList.RRF) is restricted to sixteen waterways due to display limitations. To add a new waterway, WWList.RRF should be edited and at least one name removed (the waterway file itself need not be deleted) before the new water way is created.

3.2 MENUS

3.2.1 Main Menu and Overview of Menu Use

When the program is executed, the Main Menu will automatically appear, as illustrated below:

RELATIVE RISK FACTOR MAIN MENU

Create a New Waterway
Use an Existing Waterway
Print Program Report
Configure Program
Quit

The Main Menu controls the overall operation of the program. All the submenus and Data Entry Forms are accessed through the Main Menu, as illustrated in Figure 3.2. A return to the Main Menu can be executed from any submenu by selecting such an option or by pressing [CANCEL], and from any Data Entry form by pressing [CANCEL] twice. Pressing [HELP] will present a HELP screen reviewing this material. A reproduction of this help screen appears in Appendix A.

3.2.1.1 Active Keys

The active keys for the Main Menu and the submenus follow:

RETURN, NEXT, CURSOR DOWN, TAB:	Moves the highlighted selection to the next item.
CURSOR UP:	Moves the highlighted selection to the previous item.
GO:	Executes the highlighted selection.
CANCEL:	Returns to the Main Menu if the work area is a submenu. Returns to the previous menu if the work area is a Data Entry Form. Quits if the work area is the Main Menu.

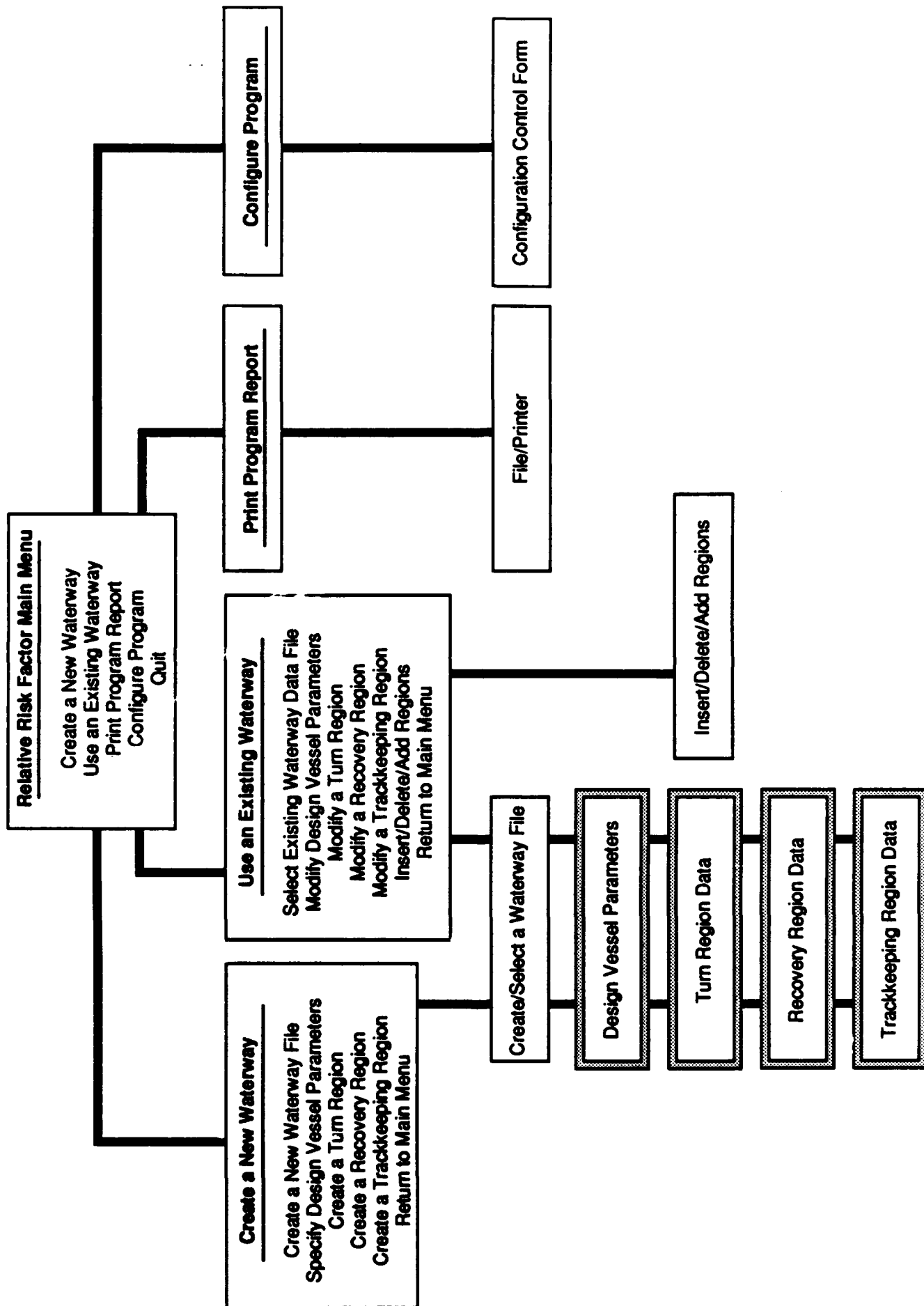


Figure 3.2 Menu Tree for Automated Relative Risk Factor Computation Program

HELP: Displays the current help screen.

FINISH: Terminates the Program from Main Menu.

3.2.2 Submenus

3.2.2.1 Create a New Waterway

When selected from the Main Menu, this submenu will appear with the following further selections:

CREATE A NEW WATERWAY

Create a New Waterway File
Specify Design Vessel Parameters
Create a Turn Region
Create a Recovery Region
Create a Trackkeeping Region
Return to Main Menu

Use this submenu to create a waterway database consisting of a file name, design vessel parameters, and up to 35 regions. (Note that the regions will later be printed in the order saved by the use of this menu. The Existing Waterway Menu includes a procedure to modify the original order of the regions.) Pressing [HELP] will present a HELP screen reviewing this material. A reproduction of this help screen appears in Appendix A.

3.2.2.2 Use an Existing Waterway

This submenu appears with the following alternatives:

USE AN EXISTING WATERWAY

Select Existing Waterway Data File
Modify Design Vessel Parameters
 Modify a Turn Region
 Modify a Recovery Region
Modify a Trackkeeping Region
 Insert/Delete/Add Regions
 Return to Main Menu

Use this submenu to select an existing waterway, or to modify vessel parameters, region features, or region order. Pressing [HELP] will present a HELP screen reviewing this material. A reproduction of this help screen appears in Appendix A.

3.2.2.3 *Print Program Report*

Use this submenu to print the Waterway Analysis Report to a file and/or to a printer. When [GO] is pressed, the screen will announce that the report is being printed to a file and/or to a printer, and will allow confirmation: Y/N. To change, select "N" and use the "Configuration Control Form" to make the desired change. To confirm, select "Y." Screen will announce that an output file is being created.

When printing to a file is complete, the first screen of the report will appear. Use [NEXT PAGE], [PREV PAGE], [SCROLL UP], and [SCROLL DOWN] to review. [FINISH] to exit.

3.2.2.4 *Configure Program*

Selection of this submenu results in the "Configuration Control Form," as illustrated on the next page.

Use this form to select the output configuration, whether the output is to be directed to a file and/or to a printer. The Program will not trap errors in a printer's name. Use Coast Guard software system commands to determine if the printer name exists.

The next entries specify file name for output. When data is printed to these files, any old data is overwritten.

The data path specified will be the volume and directory where the waterways will be saved. The path must exist and the volume must be mounted. Non-existent paths or un-mounted volumes will cause an error message and the rejection of the entry.

Automated Relative Risk Factor Computation Program

Current Waterway : MIAMI

Configuration Control Form

Print Configuration

Print to File? : N
Print to Printer? : Y
Printer ([SPL], [LPT], etc) : [ASD217]
Waterway Output file name : Waterway.Doc
Screen Print Output file name : Screen.Doc

Data/File Configuration

Data File path (vol,dir) :

[CRSR UP], [CRSR DN], [RETURN] = Change Fields.
[NEXT/PREV PAGE] = change Waterway/Region; [F4] = PrintScreen, [HELP] = Help.
[GO] = Save Results; [CANCEL] = Exit Without Saving.

3.3 DATA ENTRY FORMS

3.3.1 Use of the Forms

As illustrated in Figure 3.2, the Data Entry Forms are accessed through the first two submenus. A brief description of each form is presented in this section. Four of the forms, those indicated by darker borders in the figure, are also discussed in greater detail in Section 4.

3.3.1.1 Active Keys

NEXT, RETURN, CURSOR UP,
CURSOR DOWN, TAB:

Changes fields and records
data in a temporary file.

GO, FINISH:

Exits form, saves data.

CANCEL:

Exits form, deletes new
data.

NEXT PAGE/PREV PAGE:

Selects next or previous
region or waterway, depending
on current form, and saves
changes.

HELP:

Displays current help screen.

3.3.2 Create/Select a Waterway File

This form can be accessed from *Create a New Waterway* or *Use an Existing Waterway*. It is illustrated on the next page.

Use this form to create a new waterway file and to manage up to 16 active waterway files as instructed below. To manage more than 16 waterways, see Section 3.1.3 of this Manual.

3.3.2.1 To Create a New Waterway File

If accessed from the *Create a New Waterway* submenu, the form will appear with a new file named "New File" This name must be changed to save the file. When [RETURN] is pressed, the program will add the extension ".WWF."

Enter Waterway and File Name. Chart Number and Description are optional. Press [GO] to save and return to submenu.

Automated Relative Risk Factor Computation Program

Current Waterway : MIAMI

Create/Select a Waterway File

Waterway name : MIAMI

File name : miami.wwf

Chart number(s) : 13268

Comments/Description :

(cont) :

Active Waterway List:

miami.wwf

NewFile

Delete the current Waterway? : N

[CRSR UP], [CRSR DN], [RETURN] = Change Fields.
[NEXT/PREV PAGE] = change Waterway/Region; [F4] = PrintScreen, [HELP] = Help.
[GO] = Save Results; [CANCEL] = Exit Without Saving.

3.3.2.2 To Select an Existing Waterway File

If accessed through the *Use an Existing Waterway* submenu, the form can be used to select an existing waterway.

Press [NEXT/ PREV PAGE] keys to change waterway shown as selected at top of screen, in upper half of form, and in the Active Waterway list in lower half of form. Press [GO] to save selection and return to submenu.

3.3.2.3 To Copy an Existing Waterway File

Select the existing waterway file to be copied by using [NEXT PAGE] keys. Then change the File Name. Press [GO]. This will create a copy that can be modified; the original will be retained.

3.3.2.4 To Delete a Waterway File

Select the waterway File to be deleted by using the [NEXT/PREV PAGE] keys. Use [CURSOR UP] to bottom of screen to "Delete the current Waterway?: N." Enter "Y," and [RETURN]. "Are you sure?: N." Enter "Y," [RETURN], and [GO]. The waterway will be deleted.

3.3.3 Design Vessel Parameters

The *Design Vessels Parameters* form is accessed from either the *Create a New Waterway* or the *Use an Existing Waterway* submenus. The form must be filled out to provide the program with information needed to calculate RRF in the regions. The form contains data for a default vessel. Pressing [NEXT PAGE] will provide a blank form. Pressing the [HELP] key will provide a HELP screen. Because of the relative complexity of the required input, extended guidance is provided in Section 4.1. When the form is complete, press [GO], to save the results and return to the submenu. Each waterway file will accept only one design vessel. To examine the effect of a second vessel, copy the file as in 3.3.2.3 and change the entered parameters.

3.3.4 Turn Region Data

The *Turn Region Data* form is accessed from either the *Create a New Waterway* or the *Use an Existing Waterway* submenu. Use it to create a new turn region or to modify an existing region. Pressing the [HELP] key will provide field-dependent HELP screens. Because of the relative complexity of the required input, extended guidance is provided in Section 4.2. To save entered data, press [GO] or [NEXT PAGE].

Note that regions will be printed in the order in which they are

saved. To create the regions in the order in which they appear on the chart, use [GO] to return to the submenu and select *Create a Recovery Region* next. Use [NEXT/PAGE] to create all turn regions together. It is still possible to print a report showing successive regions in order by using the Insert/Delete/Add form described in 3.3.7 below to insert other regions between the turns.

3.3.5 Recovery Region Data

The *Recovery Region Data* form is accessed from either the *Create a New Waterway* or the *Use an Existing Waterway* submenu. Use it to create a new recovery region or to modify an existing region. Pressing the [HELP] key will provide field-dependent HELP screens. Because of the relative complexity of the required input, extended guidance is provided in Section 4.3. To save entered data, Press [GO] or [NEXT PAGE].

3.3.6 Trackkeeping Region Data

The *Trackkeeping Region Data* form is accessed from either the *Create a New Waterway* or the *Use an Existing Waterway* submenu. Use it to create a new trackkeeping region or to modify an existing region. Pressing the [HELP] key will provide field-dependent HELP screens. Because of the relative complexity of the required input, extended guidance is provided in Section 4.4. To save entered data, press [GO] or [NEXT PAGE].

3.3.7 Insert/Delete/Add Regions

Access this form through the *Use an Existing Waterway* submenu. The form is illustrated on the next page.

Use it to Insert/Delete/Add regions, as described below. It can also be used to review the order of the saved regions before printing a report.

3.3.7.1 To Insert a Region

Use the [NEXT/PREV PAGE] keys to find the region before which the new region is to be inserted. Check "Insert." Hidden fields will appear and offer the selection of a turn, recovery, or trackkeeping region. Check type. "Execute the operation?: N." Enter "Y." Press [GO] to execute. A data entry form for that region type will be inserted.

3.3.7.2 To Delete a Region

Use the [NEXT/PREV PAGE] keys to find the region to be deleted. Check "Delete." "Execute the operation?: N." Enter "Y." Press [GO] to execute. The region will be deleted.

Automated Relative Risk Factor Computation Program

Current Waterway : MIAMI

Insert/Delete/Add Regions

Current Region : K2 Description : OUTER BAR CUT

Choose an operation (check one)

Insert : X Delete : Add :

Region "NEW" will be inserted BEFORE the current region.

New Region type (check one) :

Turn Region : Recovery Region : Trackkeeping Region :

Execute the operation? : N

[CURSR UP], [CURSR DN], [RETURN] - Change Fields.
[NEXT/PREV PAGE] - change Waterway/Region; [F4] - PrintScreen, [HELP] - Help.
[GO] - Save Results; [CANCEL] - Exit Without Saving.

3.3.7.3 To Add a Region

Check "Add." "Execute the operation?: N." Enter "Y." Press [GO] to execute. A new region will be added to the end of the existing waterway. Note that a new region can also be added directly from the submenu.

**SECTION FOUR
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4.0 "JOB AID" FOR ENTERING DATA

This section provides a "job aid" for the critical Data Entry Forms : *Design Vessel Parameters*, *Turn Region Data*, *Recovery Region Data*, and *Trackkeeping Region Data*. Information that was discussed more generally in Section 2 must be structured more precisely for input into the Forms. Brief versions of the material here are available in the program through screen-or field-dependent HELP screens. Recommended limits to the input variables are summarized in Table 4.1. In some cases the program will not accept values outside these limits. In every case, results calculated using extreme or unusual values should be interpreted with caution.

4.1 DESIGN VESSEL PARAMETERS

The Data Entry Form *Design Vessel Parameters* is illustrated on the next page. The Form will appear with values for a sample vessel. If this vessel is not to be used, use [NEXT PAGE] to obtain a blank form. Pressing [NEXT PAGE] a second time will return the sample vessel. (Note that using [NEXT PAGE] will delete any entered values. To save an entered design vessel, you must copy the waterway before using [NEXT PAGE] to explore other possibilities.)

The over-all level of RRF values obtained and their accuracy for a particular waterway depends very heavily on the vessel parameters input here. Several options are possible for providing these parameters, depending on how much information is available about an appropriate design vessel and how critical the performance of the specific vessel is to the objectives of the analysis. See Section 2.2 for a discussion of the selection of the design vessel and possible conservatism. The options offered here are as follows:

- ♦ Use the default sample vessel or copy another sample vessel from Table 4.2. If one of these ships is representative of the type of ship of interest this approach may quite accurate. All the ships presented are commercial tankers or bulkers, the least maneuverable of ships. If the actual traffic in the subject waterway is not of this type, the RRF values will be conservative.

- ♦ Fill in as much information as is available on the specific design vessel and let the Program estimate missing values. In preliminary testing, RRF values obtained in this way were very close to values obtained when all parameters were available. Displacement or deadweight tonnage must be entered; the Program will estimate all other parameters from these. Enter a zero in any field to have the Program estimate any specific parameter. When the program estimates a parameter value, the estimates are marked "--". The marks remain until the estimated parameter values are replaced by the user or accepted by saving the form.

Table 4.1 Recommended Limits to Entered Data

<u>Design Vessel Parameters</u>	
Displacement (tons) :	10,000 - 500,000
Ship size (dw tons) :	9,000 - 400,000
Length (ft) :	consistent with displacement
Beam (ft) :	consistent with displacement
Loaded Draft (ft) :	consistent with displacement
Height of Eye (ft) :	any realistic value
Transit Speed (kts) :	4 - 15
Tact. Diam (osl) :	2.3 - 4
Nomoto Par. K* (-) :	.9 - 3.5
Nomoto Par. T* (-) :	1.6 - 11
<u>Region Data</u>	
Turn angle:	5 - 45
Navigable width (ft) :	300 - 1200
Extra width (ft) :	proportional to navigable width
Max <u>crosstrack</u> current (kts) :	0 - 5
Range Separation (yds) :	any realistic value
Range Distance (yds) :	any realistic value
Front/Rear height (ft) :	any realistic value

Automated Relative Risk Factor Computation Program

Current Waterway : MIAMI

Design Vessel Parameters

Displacement (tons) : Required:
and/or 42072.00
Ship size (dw tons) : 33000.00
Length (ft) : 574.00
Beam (ft) : 85.00
Loaded Draft (ft) : 37.00
Height of Eye (ft) : 76.00
Transit speed (kts) : 9.00

Use [NEXT PAGE] to switch between
default and blank vessel parameters.

Tact. Diam. (osl) : Optional:
Nomoto Par. K* (-) : 2.83
Nomoto Par. T* (-) : 1.00
Nomoto Par. T* (-) : 2.00

[CRSR UP], [CRSR DN], [RETURN] = Change Fields.
[NEXT/PREV PAGE] = change Waterway/Region; [F4] = PrintScreen, [HELP] = Help.
[GO] = Save Results; [CANCEL] = Exit Without Saving.

Table 4.2. Parameters for Sample Vessels

PARAMETERS	VESSELS						
	33k Tanker	1000-ft GL	76k Bulker	150k Bulker	150k dgrd	150k upgrd	250k Tanker
	displacement (tons)	42,072	77,500	86,174	171,240	171,240	282,924
	size (dwt)	33,000	66,000	76,000	150,000	150,000	250,000
	length (btw prp)(ft)	574	990	855	915	915	1,085
	beam (ft)	85	105	106	145	145	170
	loaded draft (ft)	37	27.5	40	52	52	61
	height of eye (ft)	76	95	81	78	78	95
	speed (kts)	9	9	9	9	9	9
	tact diam (osl)	3.83	3.2	3.34	2.78	3.04	2.38
Normoto K* (20/20)	1.2	0.95	1.33	1.94	3.5	1.45	1.98
Normoto T* (20/20)	2.22	1.62	2.87	4.68	11	2.08	4.83

VESSEL DESCRIPTIONS:

33, 000 deadweight ton (dwt) tanker
 1000-foot Great Lakes ore carrier
 76,000 dwt bulk carrier (Panamax)
 150,000 dwt coal carrier
 150,000 dwt coal carrier with degraded rudder
 150,000 dwt coal carrier with upgraded rudder
 250,000 dwt tanker

♦ Provide all parameters. The Optional parameters on the form are controllability indices that may be difficult to obtain. For most uses, they are "optional." However, if the objective of the analysis is to evaluate the effect of differences in ship controllability, rather than ship size, they are essential.

The Data Entry Screen illustrated above asks for the following items:

Displacement in long tons (tons) is the weight of the water displaced by the fully-loaded vessel. If it is not input, the program will provide an estimate from ship size in deadweight tons, when that latter parameter is input.

Ship size in deadweight tons (dw tons) is the capacity of a vessel, or the difference between loaded and light displacement. The program can estimate it from displacement. (Displacement and/or deadweight tonnage are needed to estimate controllability parameters and to adjust baseline performance for the specified ship.)

Length in feet (ft) is the vessel's length between perpendiculars (LBP). That is, two imaginary lines perpendicular to the waterline at either end of the ship. For a typical commercial ship: $LBP = 0.95 \times LOA$ (length over-all).

Beam in feet (ft) is the width of the vessel at its molded beam, or widest point. (Length and beam are used to calculate the position of the extreme points of the ship's contour.)

Draft in feet (ft) is the loaded draft, corresponding to the loaded displacement.

Height of eye in feet (ft) is the height of the shiphandler's eye from the surface of the water. It is used in the calculation of range sensitivity, and, therefore, is required only if there are ranges. Ranges are discussed in Section 4.2.

Transit speed in knots (kts) is the speed required in the waterway or that reported by local pilots. Speed is used in the calculation of the extreme points of the ship's contour. A default speed of 9 knots is suggested with the default Max crosstrack current (kts) discussed below.

Tactical Diameter (osl) is the tactical diameter in own ship lengths. The most frequently-used standard maneuver, or sea trial, is the turning circle. Usually this is done by moving the ship's rudder from midships to 35 degrees and holding it there until the ship's head changes 360 degrees. The tactical diameter is the distance perpendicular to the original line of travel that the ship moved in the time it took the head to reach 180 degrees. This distance can be expressed in "own ship lengths" by dividing by the ship's length in the same dimension. Because the U.S. Coast Guard requires that the turning circle be posted on the bridge of a ship, this parameter should be available.

Nomoto's Parameter, K^* (-), is an index of turning ability. (Both "*" and "-" indicate that a value is nondimensionalized, here by ship length.) A standard maneuver not required by the U.S. Coast Guard, but recommended by The Society for Naval Architects and Marine Engineers, is the zigzag maneuver. From midships the rudder is put over to starboard some specified amount--the values in Table 4.1 are calculated from a 20/20 zigzag--and held there until the head achieves that angle off the original heading. Then the rudder is shifted the same number of degrees to port and again held until the head catches up. Several parameters are read from a plot of this maneuver and several indices of controllability are calculated, including Nomoto's K . As a general interpretation of K , increased values represent improved turning ability. Research has shown these indices to be effective predictors of narrow channel performance. However, because they are not required, it is unlikely that they will be available.

Nomoto's Parameter T^* (-) is an index of quickness of response to steering calculated from the zigzag maneuver and nondimensionalized by ship length. Increased values of T represent slower response to the helm. The vessels in Table 4.2 have typical values for their physical parameters, except for the 150,000 dwt bulker with degraded rudder which has an unusually slow response. See K^* above.

The program actually calculates RRF values using different ship parameters for the different regions. Parameters used in the calculations include length, beam, nondimensional tactical diameter, and nondimensional K and T . Because the latter parameters may be difficult to obtain, the program also contains equations estimating the needed parameters from others that might be entered. The estimated values for missing parameters should not be taken as accurate enough for other uses. As an example, an estimated value for K^* should not be taken from the vessel screen and used as a measure of turning ability for a subject vessel. However, early testing of the ARRF program has shown that the RRF calculations are not sensitive to small differences in these parameters and RRF values calculated with estimated parameters are quite similar to those calculated with all information available. See Mazurkiewicz and Smith, 1992 for a discussion of these issues.

4.2 TURN REGION DATA

The Data Entry Form *Turn Region Data* is illustrated on the next page.

The turns are the most difficult and highest-risk maneuvers in a narrow channel transit with a deep-draft commercial ship. For accurate application of the program, the conditions in each turn must be specified carefully. Each input field is discussed below. (The illustrations of turn configuration and marking type are illustrated in the program's help screen as well as here.)

Automated Relative Risk Factor Computation Program

Current Waterway : MIAMI

Turn Region Data

Region Code : T4 Description : TURN 1

Turn configuration (check one)

NonCutoff: Cutoff: X Bend: Extra width (ft) : 500.00

Turn angle (deg) : 45.00 Day: Type (1 - 3) : 3 Conforming? : Y
Night: Type (1 - 3) : 3 Conforming? : Y

Straight segment width : 500.00 Max crosstrack current (kts) : 3.50

Range Data Sensitivity : 3.83
Separation (yds) : 675.00 Distance (yds): 2500.00
Front height (ft) : 27.00 Rear height (ft) : 49.00

RRF Day: 0.3811 Night: 0.5069 Range: 1.0000

[CRSR UP], [CRSR DN], [RETURN] = Change Fields.
[NEXT/PREV PAGE] = change Waterway/Region; [F4] = PrintScreen, [HELP] = Help.
[GO] = Save Results; [CANCEL] = Exit Without Saving.

Region Code should be Txx where T is the turn region covering the distance defined in Section 2.3.1 and xx is a unique value for that region, suggested by the Program. The user can change xx but the Program will not allow the deletion of T. This code will be used to identify the region in the Report.

Description is optional.

Turn Configuration refers to the way the turn is dredged. The options are illustrated in of Figure 4.2A. (The illustrations in this Manual are numbered to correspond to the sections in which they appear.)

- A noncutoff turn is one that allows only the width of the straight channel segment for the turn. This is the highest-risk possibility.

- A cutoff turn is widened at the turn, generally at the inside apex. This widening allows a more gradual, longer-radius turn that lowers risk. If a SRA is set inside the cutoff, consider it a noncutoff turn. If cutoff is selected, a hidden field will appear and ask for "extra width." This is the difference between the widened area approximately two ship lengths beyond the turn apex and the straight segment width beyond the widening. If the dredged portion is very short or very long, the user should make his own judgment about the point at which to measure the extra width.

- The selection of bend will access the cutoff turn data, assuming a long radius turn.

(Note that RRF values calculated for a single dredging configuration with alternative SRA arrangements can be compared, as is done in the program Report. However, values calculated for different dredging arrangements may appear inconsistent with each other: for example, cutoff turns may sometimes show higher values than noncutoffs. Such inconsistencies are the result of performance data taken from different experiments or differences in pilots' standard of caution for different configurations. Comparisons of dredging alternatives is not an appropriate objective for the use of this program.)

Turn Angle (deg) for each turn configuration is the total number of degrees of heading change from one straight segment to the next. The program treats turn angle as a two-choice variable: 0 to 20 degrees and greater than 20 degrees.

Day/Night: both lighted and unlighted SRAs may be considered for Day arrangements. Night arrangements should include only lighted SRAs.

Possible arrangements of SRAs in a turn region are illustrated in Figure 4.2. Type (1 - 3) : and Conforming?: Y arrangements are defined below

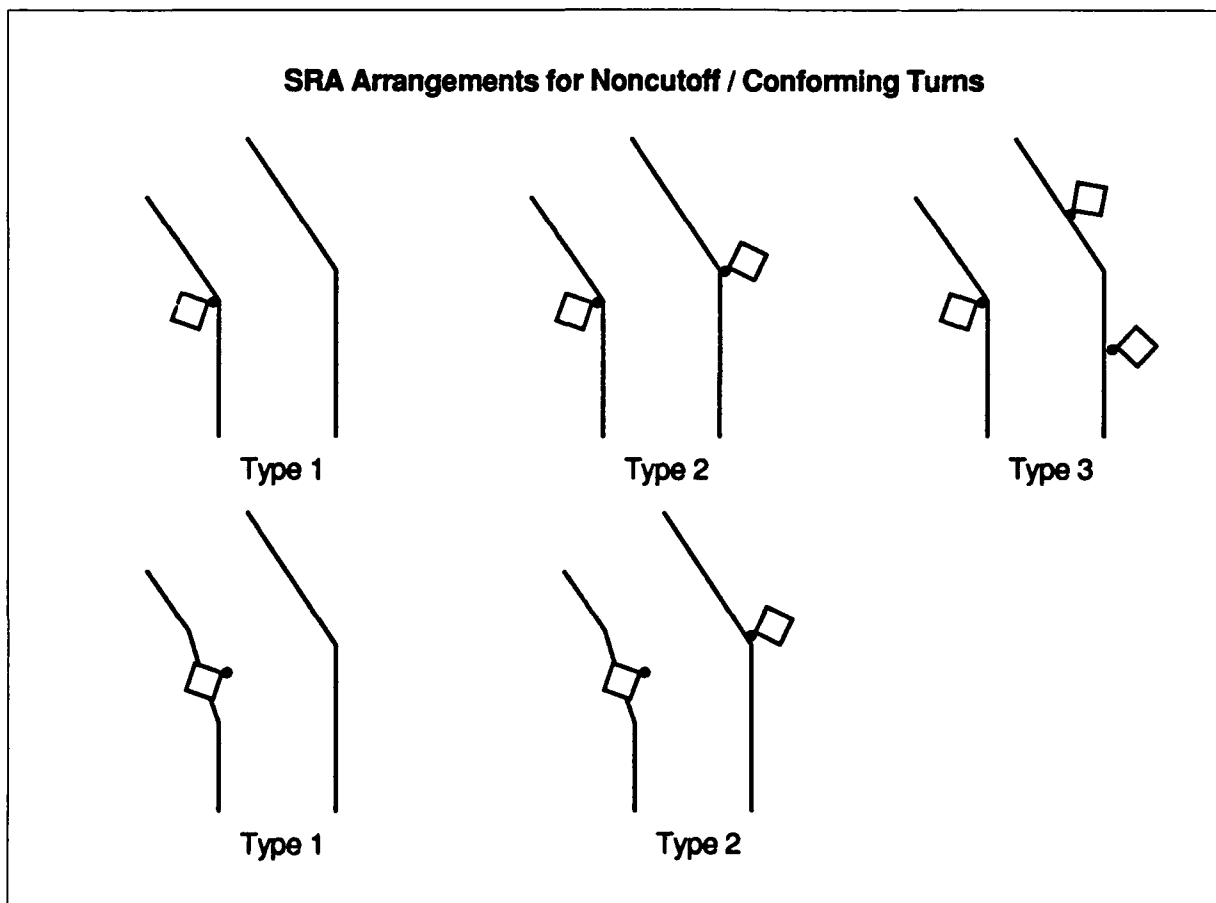
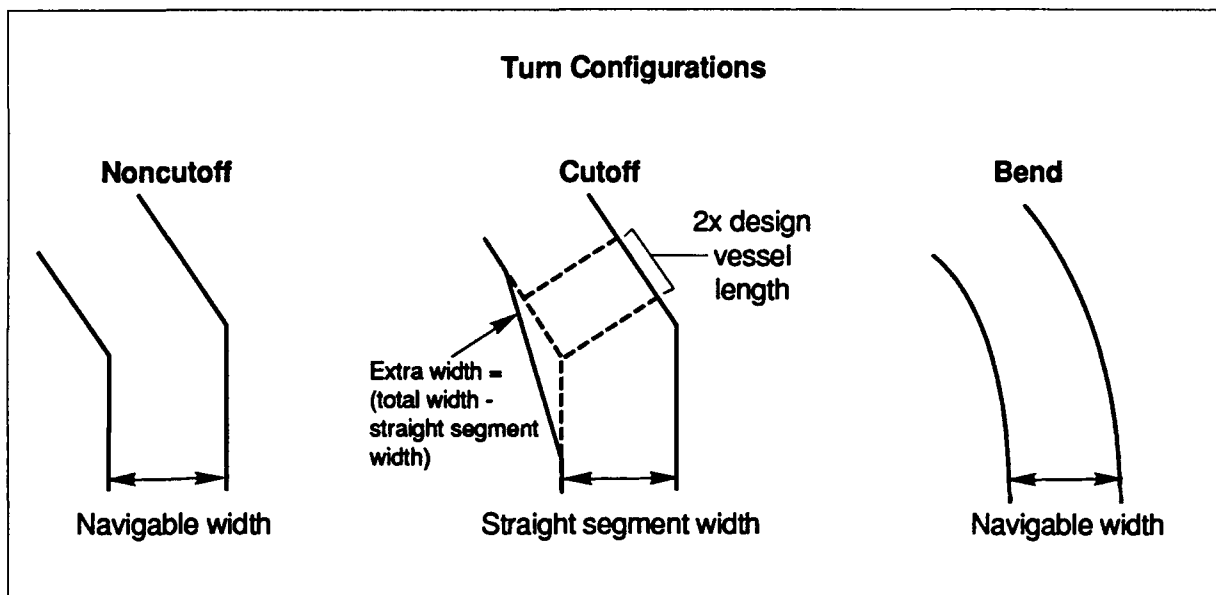


Figure 4.2A. Turn Configurations and SRA Arrangements

- Noncutoff/conforming arrangements are illustrated in Figure 4.2B. Each arrangement marks the safe water available and reflects a possible shiphandling technique. Type 1 arrangements have an inside apex SRA around which to pivot. Type 2 arrangements have gated SRAs that mark the available crosstrack distance. Type 3 arrangements have an SRA at the turn setup, the inside apex, and the turn recovery. All SRAs considered for the turn region should be within the boundaries of that region. SRAs further along the channel should be considered for the recovery region.

- Some possible noncutoff/nonconforming arrangements are illustrated in the third panel. What these examples have in common is that they do not outline the available safe water in any systematic way.

SRAs that do not outline safe water because they are off the channel edge are appropriately considered nonconforming. Very large watch circles on floating SRAs may be considered nonconforming. Obviously, there will be other possibilities. Select the conforming type to which the arrangement most closely corresponds and indicate "N." Higher RRF values will result. The program weights performance by adding the effects of 0.2 knots of crosscurrent to the entry in the current field on the form. This additional current is not shown on the screen or in the reports.

- Cutoff/conforming arrangements are illustrated in Figure 4.2C. Type 1 provides an SRA outside the dredged area but does not outline the safe water to the inside and may tempt the shiphandler to a track that is too close to the inside corners. This is the highest risk alternative. The Type 2 arrangement does mark the inside edge of the safe water. This information allows the shiphandler to move the track closer to the inside edge, making a more gradual, longer radius turn that reduces risk. Type 3 adds an outside SRA that marks the edge of the channel segment, contributing more in the approach or recovery than during the actual turn maneuver.

- Cutoff/nonconforming arrangements are illustrated in Figure 4.2C. As with the noncutoff turns, nonconforming arrangements do not outline the safe water or suggest a particular maneuver through the turn. Other nonconforming arrangements are possible. Select the type to which the arrangement most closely corresponds and indicate "N" to have the program weight performance for that turn region.

Navigable width is the width of the channel perpendicular to the channel axis that is deep enough for the design vessel at its expected draft. If cutoff turn is selected as above, "Navigable width" will change to "Straight segment width" to differentiate it from the "Extra width" allowed by dredging. See "cutoff turn" under "Turn configuration" above.

SRA Arrangements for Noncutoff / Nonconforming Turns
 (Note that the selection of "nonconforming" results in higher RRF values)

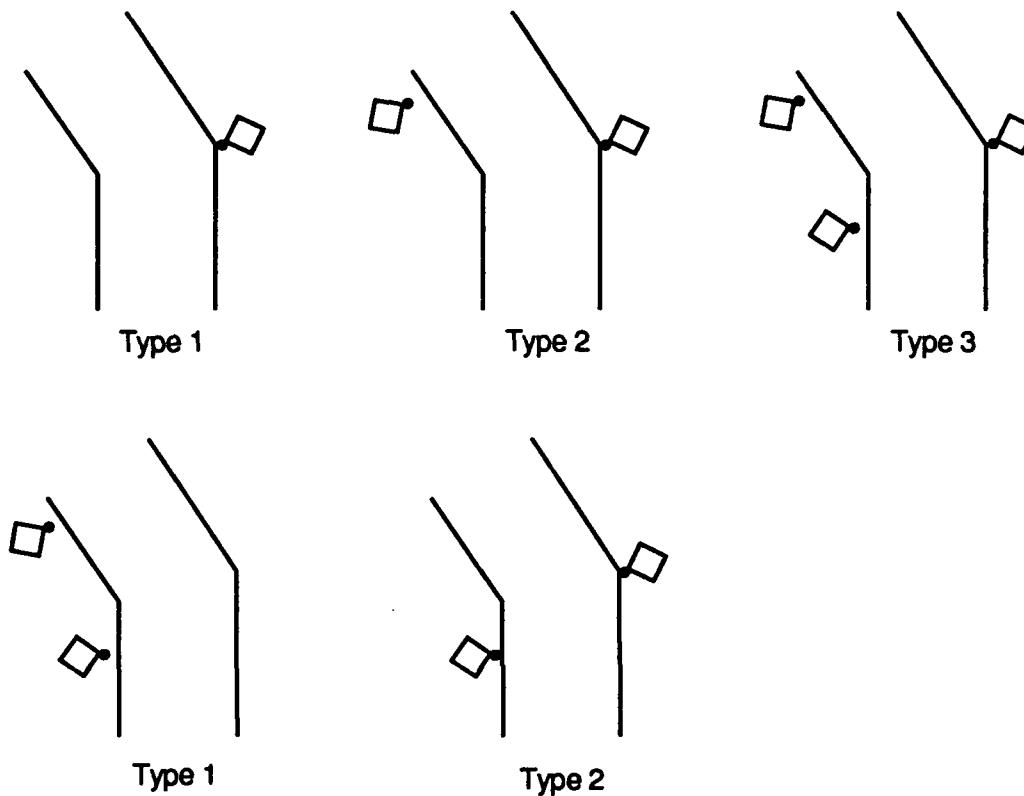
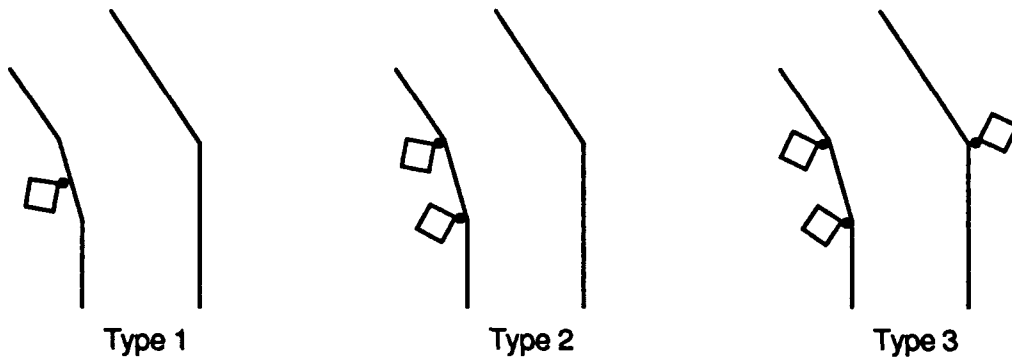


Figure 4.2B. Turn Configurations and SRA Arrangements (continued)

SRA Arrangements for Cutoff / Conforming Turns



SRA Arrangements for Cutoff / Nonconforming Turns
(Note that the selection of "nonconforming" results in higher RRF values)

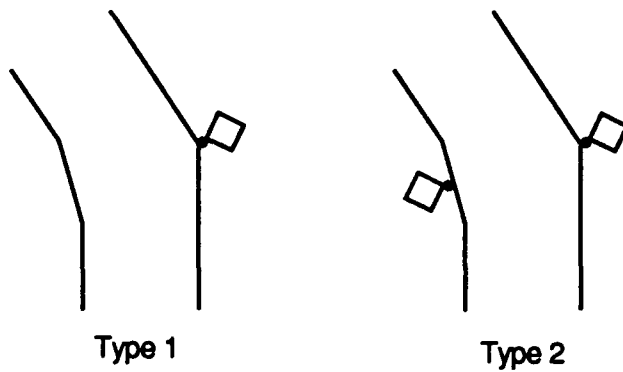


Figure 4.2C. Turn Configurations and SRA Arrangements (continued)

Max crosstrack current (kts) is the maximal velocity in knots of the crosstrack component of the current in the region. The program does not discriminate direction of current, but assumes a worst-case direction toward the outside of the turn.

A number of alternative approaches to crosscurrent are possible. The approach used should be consistent along a waterway or between waterways that will be compared. (A selection of "Conforming?: N" can be used to highlight a single particularly troublesome region. see "Conforming?: Y" above.) Alternative approaches follow:

- Use the actual crosscurrent in the region. Along with the actual ship speed, this approach will result in the most realistic RRF values. If the SRA arrangement is good and the actual current is not significant (that is, not sufficient to require a crab angle of 2 degrees or larger to hold the course of the channel), resulting RRF values may be small. If the objectives of the analysis require discrimination among the regions, an RRF value of 0.0000 in every region will not be useful and the second approach should be considered.

An additional use of actual crosscurrents is to examine the effect of different velocities of current in the same region.

- Use the default crosscurrent of 0.50 knots, along with the default ship speed of 9 knots, as a weight that will result in generally higher RRF values. There are a number of reasons to use this approach. If RRFs calculated with actual current do not discriminate among regions or alternative markings, higher values may enhance discrimination. Turns are likely to show the highest RRF values. For recovery and trackkeeping regions, values of 0.0000 even with such a weight will indicate that the combination of ship, channel width, and SRAs is relatively low risk. Conservative estimates of risk might be appropriate throughout a waterway for such reasons as high frequency of traffic, hazardous cargos, frequent poor visibility, etc. The default crosscurrent could be used as a weight throughout the waterway with the actual crosscurrent in each region added to it, showing the effect of actual variations in current.

Range Data is used by the program first to calculate "k." a measure of lateral sensitivity, and then to calculate RRF for the region with a range. For a turn region, the relevant range is the one to be used in the departure from the turn. The equation used is: $k =$

width x separation

distance x (rear hgt-front hgt)-separation x (front hgt-eye hgt)

when all dimensions are in feet. For convenience, the Program accepts each input in the dimensions in which it appears on the chart.

- Separation (yds) is the distance between the rear and front structures, as measured from the chart. Assume that one nautical mile (nm) equals 6076 feet.

- Front height (ft) is the height of the front structure, as indicated on the chart.

- Distance (yds) is from the eye point to the front structure. The distance from the end of the region farthest from the structure will yield the lowest sensitivity and the most conservative RRF value.

- Rear height (ft) is the height of the rear structure, as indicated on the chart.
(Width has already been indicated on the region data form; eye height has been indicated on the Design Vessel Parameters form.)

The program treats range sensitivity as a two-level variable. K values less than three are considered low sensitivity and will result in higher RRF values; three or higher is considered high sensitivity and will result in lower RRFs. If k is calculated as less than three, a hidden field will appear at the bottom of the form, reading "Upgraded Range: x.xxxx." This is the RRF value that would be obtained for the conditions with a high-sensitivity range.

The Program makes no special provision for an aft range. A treatment consistent with that provided for a "nonconforming" sidemark arrangement, as described above, would be the addition of a crosscurrent of 0.20 knots to the actual or default current entered for the region. To obtain this value, add the extra current, make a note of the RRF value, and subtract the extra current. Leaving in the extra current will affect the calculations for the Day and Night values for the sidemark arrangements. If the range is used equally as a forward and an aft range, the higher risk value may be the more conservative and appropriate. If the pilots report using the range only as an aft range, the higher risk value will be more appropriate.

RRF Day: x.xxxx: "Not ready" appears on the new form. When enough data has been entered to allow calculation of a daytime RRF, a value will appear. This value reflects the day arrangement indicated on the form and whether that arrangement was conforming or not. This value will appear again in the Report on the daytime "totem pole."

Night: x.xxxx: "Not ready" appears on the new form. When enough data has been entered to allow calculation of a nighttime RRF, a value will appear. This value reflects the night arrangement indicated on the form and whether that arrangement was conforming or not. This value will appear again in the Report on the nighttime "totem pole."

Range: x.xxxx: "Not ready" appears on the new form. When enough data has been entered to allow calculation of a range RRF, a value will appear. This value reflects the range sensitivity calculated above. This value will appear again in the Report on the range "totem pole."

Upgraded range: x.xxxx: See "Range data" above. This value does not appear in the Report on the "totem pole" but does appear in the "Configuration Options" block for the region.

4.3 RECOVERY REGIONS

The Data Entry Form *Recovery Region Data* is illustrated on the next page.

A recovery region follows each turn. Generally, risk will be substantially lower than it is in the turn, and, generally, higher than it is in the following trackkeeping region. For accurate application of the evaluation process, the conditions in each turn must be specified carefully. Each input field is discussed below.

Region Code should be Rxx where R is the recovery region covering the distance defined in Section 2.3.2 and xx is a unique value for that region suggested by the Program. The user can replace xx but the Program will not allow the deletion of R. This code will be used to identify the region in the Report.

Description is optional.

Navigable width : See Section 4.2 Turn Region Data.

Max crosstrack current (kts) : See Section 4.2 Turn Region Data. Discussion of alternative approaches applies here.

SRA configuration:

For accurate application of the program, several arrangements and spacings of SRAs are illustrated in Figure 4.3A. Select the arrangement that most closely resembles the marking on the chart. (Note that a similar illustration is available in the program as a help screen.)

Day/Night: both lighted and unlighted SRAs may be considered for Day arrangements. Night arrangements should include only lighted SRAs.

Automated Relative Risk Factor Computation Program

Current Waterway : MIAMI

Recovery Region Data

Region Code : R5 Description : TURN 1 WEST

Navigable width (ft) : 500.00 Max crosstrack current (kts) : 3.50

SRA configuration:

Day: Gated(S): X Gated(L): Staggered(S): Staggered(L): 1-side:
Night: Gated(S): X Gated(L): Staggered(S): Staggered(L): 1-side:

Day: Conforming? : Y Night: Conforming? : Y

Range Data Sensitivity :
 Separation (yds) : Distance (yds):
 Front height (ft) : Rear height (ft) :

RRF Day: 0.2194 Night: 0.3781 Range: Not Ready

[CRSR UP], [CRSR DN], [RETURN] - Change Fields.
[NEXT/PREV PAGE] - change Waterway/Region; [F4] - PrintScreen, [HELP] - Help.
[GO] - Save Results; [CANCEL] - Exit Without Saving.

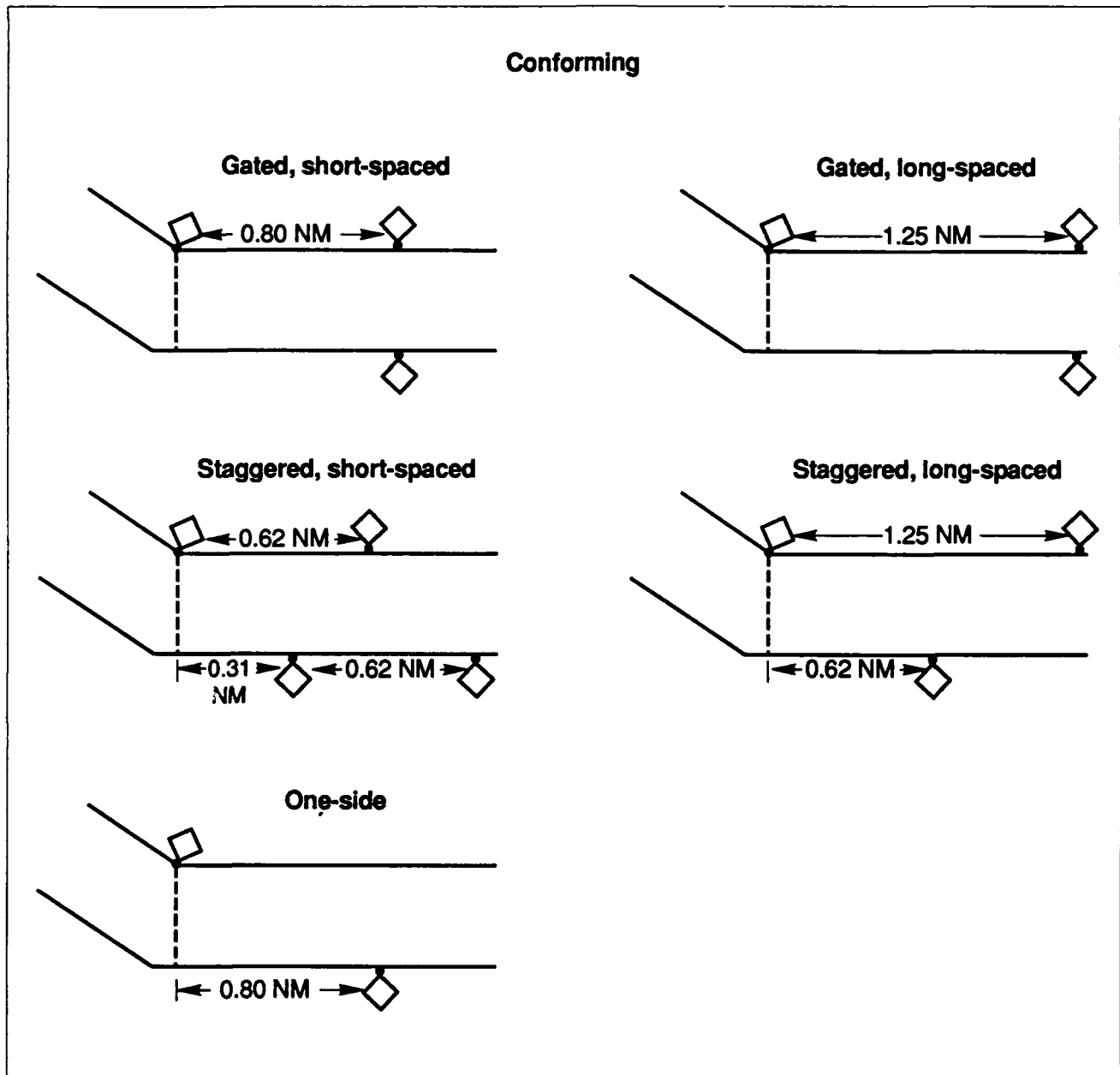


Figure 4.3A. Recovery Region SRA Arrangements

RECOVERY REGION, SRA ARRANGEMENTS

NONCONFORMING:

(Note that the selection of nonconforming will result in higher RRF values.)

- Gated, short-spaced, nonconforming
- Gated, longer-spaced or nonconforming
- Staggered, short-spaced, nonconforming
- Staggered, longer-spaced or nonconforming
- One-sided, longer-spaced or nonconforming

Figure 4.3B. Recovery Region SRA Arrangements (continued)

- A gated arrangement is one in which the SRAs are opposite each other on a line perpendicular to the channel axis. This arrangement allows the pilot to accurately find the centerline of the channel by "splitting the gates," resulting in the lowest RRF values in the recovery region. If the spacing between the turn apex and the first gate and between successive gates is 0.80 nm or less, the spacing is short: (S). If the spacing is 1.25 nm or less, the spacing is long: (L). Note that the first distance is between the turn apex or an SRA and the first gate, not between the edge of the turn region and the gate.

- A staggered arrangement is one in which the SRAs appear alternately on opposite sides of the channel. This arrangement may encourage "buoy hopping," approaching first one SRA and then the other. Frequent changes in heading result in higher risk than does the maintenance of the centerline, the technique that is encouraged by a gated arrangement. If the spacing between two SRAs on a side is 0.62 nm or less, the spacing is short: (S). If the spacing is 1.25 nm or less, the arrangement is long spaced (L). Note the distance to the first SRA after the turn is the most critical to recovery performance. Exactly what is an effective arrangement for a recovery region marked with staggered SRAs will depend on how the turn region is marked. Distances should be measured from turn SRAs, not from the edge of the turn region.

- A one-sided arrangement is one with SRAs placed along one side of the channel. Other things being equal, such arrangements will result in the highest RRF values because they make it difficult for the pilot to judge his ship's crosstrack position in the channel.

Conforming?: Y is specified for day and night separately. Reasons why an arrangement might be designated "N" include irregularities of placement, longer spacing than specified, SRAs off the channel edge, spacing that is questionable for the distribution of visibilities in the area, or an operational practice of meeting traffic in the region. Higher RRF values will result from the specification of "N." The program weights performance by adding the effects of 0.2 knots of crosscurrent to the entry in the current field on the form. This additional current is not shown on the screen or in the reports.

Range Data: See Section 4.2 Turn Region Data.

RRF Day: x.xxxx: See Section 4.2 Turn Region Data.

Night: x.xxxx: See Section 4.2 Turn Region Data.

Range: x.xxxx: See Section 4.2 Turn Region Data.

Upgraded range: x.xxxx: See Section 4.2 Turn Region Data.

4.4 TRACKKEEPING REGIONS

The Data Entry Form *Trackkeeping Region Data* is illustrated on the next page.

When turn and recovery regions are subtracted from a straight channel segment, what is left is a trackkeeping region. Generally, risk will be lowest in this region. For accurate application of the program, the conditions in each trackkeeping region must be specified carefully. Each input field is discussed below.

Region Code should be Kxx where K is the trackkeeping region covering the distance defined in Section 2.3.3 and xx is a unique value for that region, suggested by the Program. The user may replace xx, but the Program will not allow the deletion of K. This code will be used to identify the region in the Report.

Description is optional.

Navigable width : See Section 4.2 Turn Region Data.

Max crosstrack current (kts) : See Section 4.2 Turn Region Data. The discussion of alternative approaches applies here.

SRA configuration:

For accurate application of the program, several arrangements and spacings of SRAs are illustrated Figure 4.4A. Select the arrangement that most closely resembles the marking on the chart. (Note that a similar illustration is available in the program as a help screen.)

Day/Night: See Section 4.2 Turn Region Data.

- A gated arrangement is one in which the SRAs are opposite each other on a line perpendicular to the channel axis. If the spacing between successive gates is 0.80 nm or less, the spacing is short: (S). If the spacing is 1.25 nm or less, the spacing is long: (L). Distances should be measured from the last SRAs in the recovery region, not from the edge of that region. (Trackkeeping with gated arrangements will sometimes produce unexpectedly high RRF values. This results from relatively-high baseline performance data that reflect a shift in the pilot's standard of caution for such a situation.)

Automated Relative Risk Factor Computation Program

Current Waterway : MIAMI

Trackkeeping Region Data

Region Code : K6 Description : GOVT CUT

Navigable width (ft) : 400.00 Max crosstrack current (kts) : 0.00

SRA configuration:

Day:	Gated(S): X	Gated(L):	Staggered(S):	Staggered(L):	1-side:
Night:	Gated(S): X	Gated(L):	Staggered(S):	Staggered(L):	1-side:

Day:	Conforming? : Y	Night:	Conforming? : Y
------	-----------------	--------	-----------------

Range Data	Sensitivity :
Separation (yds) :	Distance (yds):
Front height (ft) :	Rear height (ft) :

RRF Day: 0.0000 Night: 0.0000 Range: Not Ready

[CRSR UP], [CRSR DN], [RETURN] = Change Fields.
[NEXT/PREV PAGE] = change Waterway/Region; [F4] = PrintScreen, [HELP] = Help.
[GO] = Save Results; [CANCEL] = Exit Without Saving.

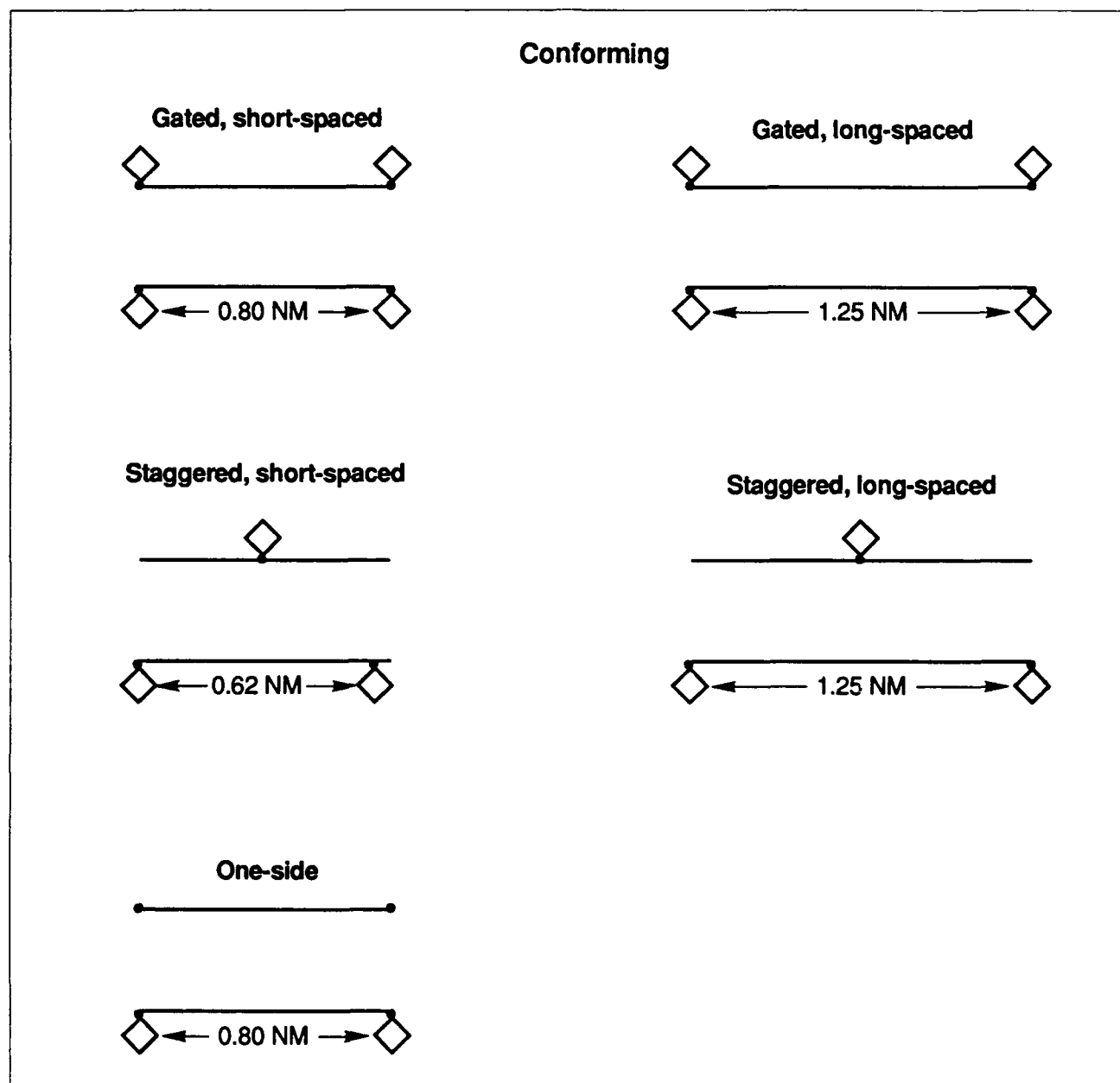


Figure 4.4A. Trackkeeping SRA Arrangements

TRACKKEEPING REGION, SRA ARRANGEMENTS

NONCONFORMING:

(Note that the selection of nonconforming will result in higher RRF values.)

- Gated, short-spaced, nonconforming
- Gated, longer-spaced or nonconforming
- Staggered, short-spaced, nonconforming
- Staggered, longer-spaced or nonconforming
- One-sided, longer-spaced or nonconforming

Figure 4.4B. Trackkeeping Region SRA Arrangements (continued)

- A staggered arrangement is one in which the SRAs appear alternately on opposite sides of the channel. This arrangement may encourage "buoy hopping," approaching first one SRA and then the other. Frequent changes in heading result in higher risk that the maintenance of the centerline encouraged by a gated arrangement. If the spacing between two SRAs on a side is 0.62 nm or less, the spacing is short: (S). If the spacing is 1.25 nm or less, the arrangement is long spaced: (L). Distances should be measured from the last SRAs in the recovery region, not from the edge of that region.

- A one-sided arrangement is one with SRAs placed along one side of the channel. Other things being equal, such arrangements will result in the highest RRF values because they make it difficult for the pilot to judge his ship's crosstrack position in the channel. Distances should be measured from the last SRAs in the recovery region, not from the edge of that region.

Conforming?: Y: See Section 4.3 Recovery Region Data.

Range Data: See Section 4.2 Turn Region Data.

RRF Day: x.xxxx: See Section 4.2 Turn Region Data.

Night: x.xxxx: See Section 4.2 Turn Region Data.

Range: x.xxxx: See Section 4.2 Turn Region Data.

Upgraded range: x.xxxx: See Section 4.2 Turn Region Data.

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5.0 INTERPRETATION AND APPLICATION OF THE RESULTS

5.1 WATERWAY ANALYSIS REPORT

The Waterway Analysis Report is printed by instructions appearing in Section 3.2.2.3. A sample report appears as Appendix B.

The first block on the report repeats the inputs for Waterway, File Name, and Comments from the *Create/ Select a Waterway File* form described in Section 3.3.2.

The second block repeats the inputs for the *Design Vessel Parameters* Form described in Sections 3.3.3 and 4.1.

The third block is the "totem pole," drawn within the capabilities of the alphanumeric terminal of the USCG Standard Work Station. The totem pole is a vertical axis representing a range of RRF values, here from less than or equal to .000 to equal to or greater than .900. Three such poles are presented here, labeled "Day," "Night," and "Range." On each pole are plotted the RRF values for each region taken from the *Region Data* Forms described in Sections 3.3.3, 3.3.5, 3.3.6 and 4.2, 4.3, and 4.4. Each region is represented by the Region Code given it on the Form. Approximately six region codes can appear on the same line of the plot. If there are additional regions at a single RRF value, they will not appear on the plot, but they will be included in the rest of the report. The purpose of the plot is to sort the regions by RRF values and isolate those regions with conspicuously high risk for special consideration. The application of this plot is discussed further in Section 5.2 that follows.

The following blocks on the report are reproductions of each *Region Data* Form with all its inputs and the calculated RRFs as they were presented on the screen. These forms are described in Sections 3.3.3, 3.3.5, 3.3.6 and 4.3, 4.4, and 4.5. They are printed in the order in which they were saved. The reproduction of these forms serves as a record of what was input and of what the RRFs are for the input conditions, presumably the actual conditions.

The final blocks repeat the sequence of regions with *Region Configuration Options*. For each region, the block reproduces the Region Code, Region Description, Region Width, Cross Current, and, for turn regions, the Turn Angle and Turn Type. These reproduced inputs are followed by calculated RRF values for these conditions and all the alternative SRA systems that the Program considers: short and long gated, short and long staggered, one sided, all these for day and night, and high and low sensitivity ranges. The purpose of this presentation is to allow the easy examination of all the "configuration options" for the conditions in the region. The application of these options is discussed in Section 5.2, which follows.

5.2 RISK MANAGEMENT

5.2.1 Introduction

The design process as directed by the Manual to this point has been involved with risk assessment, the measurement of the risk of specified conditions and the provision of a quantitative measure of this risk, the RRF. The remainder of this section involves risk management, the application of the results to the broader objectives of the system designer. While the RRF is a valuable measure, its relative nature limits its use in management to the comparison of alternative arrangements or conditions. The nature of the RRF measure was discussed here in Section 1.1. The following discussion describes two basic techniques that proceed by comparison, and discusses the support of management objectives by these techniques.

Some of the objectives discussed here are relevant to the direction provided in Aids to Navigation Manual - Administration, Chapter 3 Establishment, Review, and Modification of Coast Guard Aids to Navigation Systems.

5.2.2 Designing for Comparable Risk at Least Cost

"Designing for comparable risk at least cost" is recommended as the primary technique because it includes the possibility of controlling costs. It is applied below to a variety of management objectives. They are arranged by the degree of complexity required in selecting an appropriate comparison or baseline standard of risk. For the first three, all comparisons are made within one waterway and all calculations needed are already available in the Waterway report described in Section 5.1. The next three require copying the Waterway file and changing some of the conditions. The last one is the most complex in that it requires the use of another waterway for comparison.

5.2.2.1 To Seek Uniform Risk Within a Waterway

The establishment of uniform risk throughout a waterway is recommended as a first, basic objective of management within a waterway. The totem pole readily serves this objective. One version is included in the Waterway report described in Section 5.1 and presented as Appendix A. First, examine the plot for conspicuously high risk regions. Note that the highest risk regions will usually be turn regions. The differences in severity of the maneuvers will limit just how uniform risk can be. Look also for conspicuous difference among the subsystems of day, night, and range. If there is a dependence on unlighted SRAs, there may be a difference between day and night, especially in difficult turns. If so, the nighttime subsystem should be carefully re-considered for its adequacy in providing the needed service.

If there are ranges present, there may be considerable difference between visibilities that allow their use and those that do not. Does the distribution of expected visibilities justify dependence on ranges? Is there a need to improve the system of sidemarks for lower visibilities?

The original version of the Totem pole appears as Figure 5.2. In the figure the axis is a multi-cycle logarithmic scale. Note that it preserves the order of the RRF values but not the intervals between them. The resolution is high for the lower RRF values but decreases for the higher values. The values from 0.1 to 1 are compressed into the top quarter of the scale. The figure can be copied and regions of special interest plotted to support management decisions.

5.2.2.2 Prioritize Work Within a Waterway

A companion objective to the establishment of uniform risk is the assignment of priorities for work within a waterway. Regions and subsystems identified as having conspicuously high risk within the waterway should be given the highest priority for work.

5.2.2.3 To Justify Reduction in Service Within a Waterway

Some regions may have conspicuously low risk, suggesting them as candidates for low priority and even for a reduction in service. However tempting a reduction in service may be, caution is necessary. Re-examine the region for the presence of risk factors such as those listed in Section 2.4, factors such as shoals, currents, close turns, etc. Consider such transient increases in risk as meeting traffic or reduced visibility, discussed further in Section 5.2.4 below. Include appropriate user groups early in the process to receive their input and increase their final acceptance. Look into historical reasons for the original markings. If the reduction in service follows from a policy of seeking uniform risk, an SRA may be shifted from a region of low risk to a region of high risk and the change presented as an increase in overall service in the waterway.

5.2.2.4 To Evaluate Requests for Change

Consideration of changes to existing conditions is somewhat more complex in that the needed calculations are not readily available from a single Waterway report. New calculations for the new conditions are needed. Care should be taken that the only differences between the original, baseline conditions and the new conditions are those of interest and that there are no unwanted differences to bias results. Comparisons may be relatively simple and certain if historical conditions provide an appropriate baseline or standard against which to examine the new conditions. As an example, if there is a request for an improvement in the

WATERWAY NAME AND LOCATION: _____

DESIGN/EVALUATION OBJECTIVE: _____

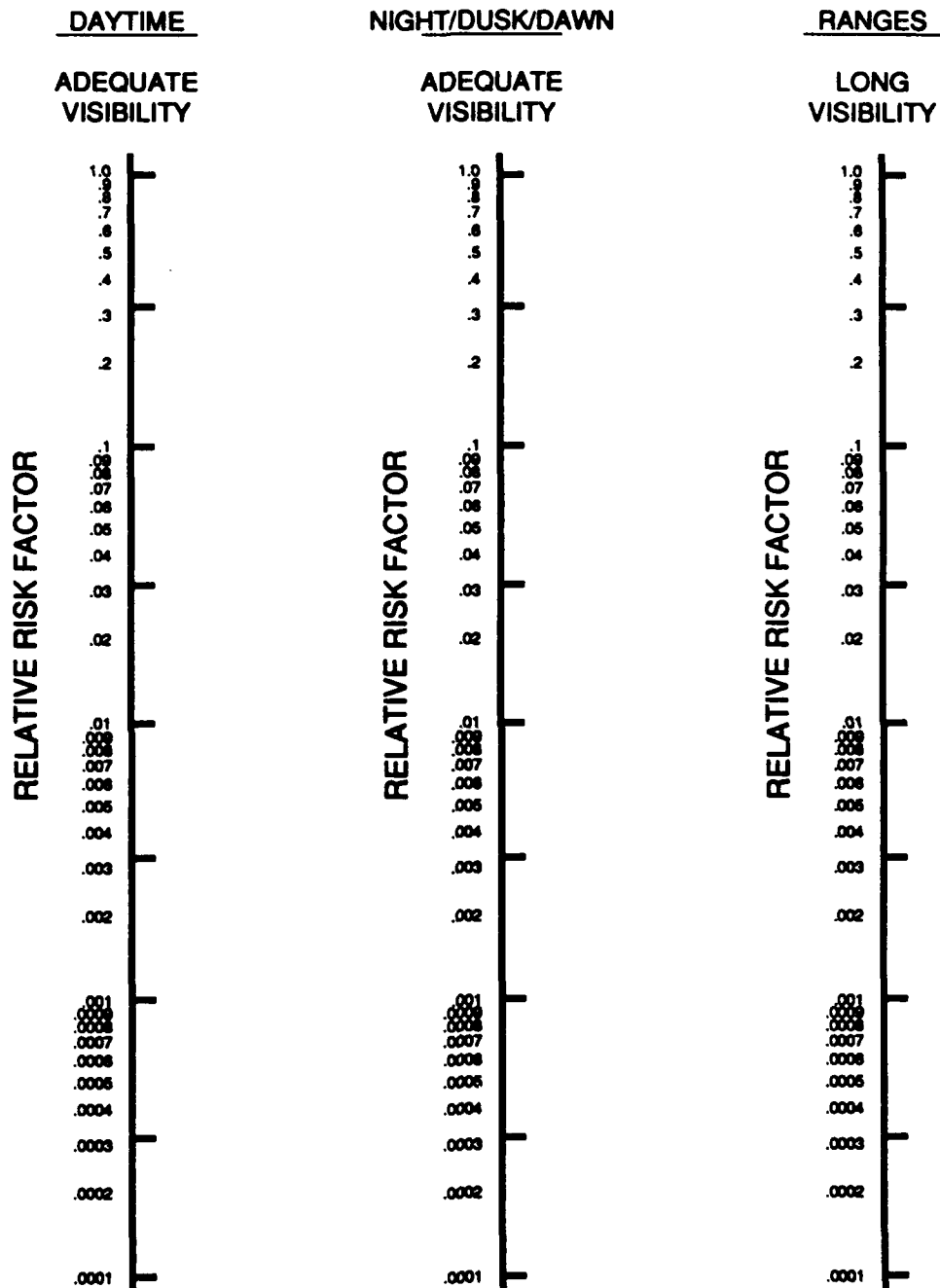


Figure 5.2 "Totem Pole" for Graphic Summary of Relative Risk Factor (RRF) Values for Single Waterway

nighttime subsystem, the present nighttime subsystem will set an upper level for risk and the daytime subsystem will set a lower limit for what can be expected. Copy the original Waterway file according to the instructions in Section 3.3.2.3 and change the nighttime SRAs as requested. Instructions for input are in Sections 3.3.4, 3.3.5, 3.3.6, 4.3, 4.4, and 4.5. The requested changes can be evaluated in such a context.

5.2.2.5 To Respond to Changes in Operations

A related objective is a response to changes in operations. An example would be a request for entry to the port for a larger ship than has been customary in the waterway. Historical experience with a smaller ship presents an appropriate baseline. Copy the smaller ship's Waterway file as directed in Section 3.3.2.3 and change the design vessel parameters as instructed in Sections 3.3.3 and 4.2. Risk with the larger ship can be compared to risk with the smaller or baseline ship. If they are conspicuously different, an effort should be made to lower risk with the larger ship to that obtained with the smaller. The *Configuration Options* in the Waterway report may offer SRA system changes that lower the risk. Note that the comparison being made in this second step is the small ship with SRA Arrangement A versus the large ship with SRA Arrangement B. As an alternative to SRA system changes, operational restrictions might be placed on the larger ship. Such restrictions are discussed in Section 5.2.3 below.

5.2.2.6 To Justify Reductions in Response to Decreased Needs

Changes in operations may suggest the possibility of decreasing service. For example, larger ships may discontinue visits to a port. In this case, the larger ship may offer a baseline and the same level of risk may be achieved by a smaller ship with fewer SRAs. The designer is cautioned to consider all factors which may contribute to risk, or to the perception of risk, before such a reduction.

5.2.2.7 To Use a Second Waterway As Baseline

A single waterway will not always provide the needed standard for comparison. As an example, consider the larger ship in Section 5.2.2.5. It may not be possible to lower its risk to that of the smaller ship. One can consider the possibility that the level of risk for the smaller ship is lower than is really needed. For this consideration, compare the risk of the larger ship in the subject waterway to the risk of that ship in another waterway where it does have a history of safe passage. For another example, the risk in a waterway when its range is obscured might be compared to that in a waterway with similar conditions that never had a range.

Using a second waterway to establish a standard is less simple in that it involves additional work in the selection and analysis of the other waterway. It is also less certain in that the potential for bias in the comparison is much increased. The most certain comparison is one between conditions that differ on only one factor (for example, ship size or day/night). When a second waterway is used, many factors may differ. Sections 2 and 4 here provide a substantial list of the factors that can affect performance or a measured RRF and must be considered in establishing an appropriate comparison.

5.2.3 Designing for Minimum Risk

5.2.3.1 To Ensure Safety for Sensitive Cargoes or Environments

There may be times when the appropriate objective is to design a waterway for the "minimum risk" possible in the waterway. Obvious examples are the transit of hazardous cargoes through fragile ecosystems or through areas of high population density. Such a system will not be the lowest cost and the need for safety should justify added cost. See the Aids to Navigation Manual - Administration Chapter 3 for guidance on justifying cost.

There are a number of approaches to designing for minimum risk. One is to examine the *Configuration Options* in the Waterway report for the SRA arrangement that results in the lowest risk. Consider ranges if they are not already present, if the problems are not in the turns, and if the local visibilities justify their use. Reject any arrangement that requires a greater number of SRAs to achieve the same or nearly the same risk as the existing system.

If a satisfactory "minimum" risk cannot be achieved in all regions by the use of SRAs consider the following low risk conditions:

- ♦ daylight, with or without the addition of extra unlighted aids
- ♦ long visibilities, with added ranges
- ♦ slack current and minimum wind
- ♦ one way operations.

If one of these restrictions will bring the risk sufficiently low, consider recommending to the Captain of the Port that operations be restricted to the safest conditions.

If such restriction will not bring risk low enough, consider:

- ♦ a wider channel
- ♦ cutoff turns

If these changes do bring risk down, consider recommending this dredging to the U.S. Army Corps of Engineers. (Performance data

for cutoff and noncutoff turns may not be appropriately comparable.)

Additional possibilities are discussed in Section 5.2.4.

5.2.3.2 To Establish the Lower Limit of Risk for the Waterway

The system designer might want to design for minimum risk, as in Section 5.2.3.1, to establish the lower limit of risk for the waterway. The intention might not be to implement the resulting design, but to compare what-is to what-might-be. The comparison might support the argument--addressed to the mariner--that the existing system is at or near the minimum risk. Or it might support the argument--addressed to Headquarters--that it is far from the minimum and needs additional resources for improvement.

5.2.4 Transient Conditions and Waterway Risk

The primary objective of the design process presented here, and of the simulator experiments that provided the needed performance data, was to evaluate the contribution of SRA systems to the total risk in a waterway. In serving this objective, simplifying assumptions were made and some complicating, transient factors were omitted. To evaluate the service provided by the SRAs, competing sources of information which the pilots might use instead of or in addition to these aids were omitted. These included land masses and targets of opportunity, bank or sidewall effects, radar, and electronic navigation systems. For the sake of simplicity in analysis, other elements omitted included floating SRAs and on-coming traffic. Although not included in the design process here, the effects of these factors were evaluated by simulator experimentation. A brief overview of the principal findings of these additional findings is included here to assist in the final understanding and management of risk in a waterway.

5.2.4.1 Targets of Opportunity or Landmass

The Aids to Navigation Manual - Administration Chapter 4 states that "aids only supplement natural and manmade landmarks...existing geographic composition must be considered throughout the design process." In response to this statement of priority, the findings of one experiment deliberately manipulated the trade-off between SRA system and the features of a nearby landmass (Brown, Smith, and Forstmeier, 1988). The principal conditions evaluated and conclusions drawn included the following:

- ♦ A baseline channel marked with three aids in the turn, long-spaced gates in the straightaways, and no land in sight showed the best performance. No combination of lower density of aids and landmass was as good. When performance is critical, SRAs must support it.

Land within 2.5 nautical miles (nm) of the channel did improve performance with a lower density of aids. Performance varied with density of land-based objects and the distance to land. Benefits were greatest in the turn region, less in the recovery, and least in the trackkeeping. The findings are consistent with the principle that the complexity of the visual environment contributes to the pilot's ability to judge relative motion during maneuvers. Fixed lights close to the turn region make a particularly valuable contribution at night.

Under limited conditions, conspicuous objects provide special benefits. A target of opportunity is an effective addition when the pilots report (and agree) that they consistently make use of it and it is within 0.5 nm of the channel edge at the region for which it is being considered. For this single region, assume that the risk is equal to the best value in the *Configuration Options Report*.

5.2.4.2 Floating SRAs

The Aids to Navigation Manual - Positioning describes floating aids according to their Accuracy Classifications, the distance from the charted position within which a floating aid can be expected to lie. The principal results of an experiment (Brown, Smith, and Conway, 1989) designed to evaluate the effects of difference in accuracy of position are as follows.

Performance deteriorates, or risk increases, with the distance of aid displacement because pilots compensate for some but not all of it. When the displacement is caused by current, the crab angle required of the ship increases the effective beam and increases risk further.

Performance is affected in complex ways by the direction of the current and the resulting displacement. Effects can be favorable or harmful for a particular maneuver.

5.2.4.3 Meeting Traffic

The meeting of two large, commercial ships in a narrow channel may be the greatest risk in a transit and its lack of inclusion in an analysis may affect the credibility of the results. A dedicated experiment was run to determine whether the design guidelines derived from the pool of data on one-way transits was equally valid for two-way transits (Moynahan and Smith, 1985; Smith, Marino, and Multer, 1985). Results were not quantitatively comparable because risk in this single experiment was expressed as the combined risk of grounding and collision. The general conclusion was that the best arrangements for one-way traffic were the best arrangements for two-way traffic. A brief review of the findings follow:

♦ The beneficial effects of Type 3 rather than Type 2 marking continued far down the next leg. After a good turn, short-spaced gates were only slightly better than long-spaced gates.

♦ Bank effects tended to keep the ships away from the channel edge, verifying the conservatism of data collected without such effects.

♦ The risk is much greater if ships must meet before recovery is complete.

♦ The effects of ship size go beyond the obvious fact that a larger ship takes up more crosstrack space in the channel. A larger and less maneuverable ship tends to hold its track in the channel, putting greater burden on the on-coming ship to maneuver.

5.2.4.4 Radar or Electronic Navigation Displays, in Reduced or Full Visibility

While it is U.S. Coast Guard policy to provide SRA system for visual piloting, commercial ships and highly trained pilots do make substantial use of radar. To investigate the relation between visual piloting and the use of radar, a dedicated experiment was run, adding to the simulation a simple, generic plan position indicator (PPI) display and passive reflectors on the SRAs (Smith, Marino, and Multer, 1985; Multer and Smith, 1983). The general conclusion was that the best arrangement of SRAs for visual piloting is also the best for radar piloting. Principal findings included the following:

♦ Pilots reported that they prefer visual piloting and resist getting underway without adequate visibility. When forced to get under way under marginal conditions, they usually do not combine methods but give dominance to whichever is expected to be most useful for most of the transit. The other method becomes secondary.

♦ In the turn region, radar and visual piloting do enhance each other. Pilots used radar range to the turn apex to start the turn, starting earlier than they did with visual alone, an action that contributes to a superior turn. After the start of the turn, they switched their attention to the visual SRAs to judge the angular motion of the ship around the apex.

♦ In the recovery and trackkeeping regions, radar and visual piloting did not combine as well. Performance with radar and gated SRAs was poorer in reduced visibility than it was in zero visibility. Apparently, switching between radar and SRAs for crosstrack position was a distraction.

♦ The best radar performance was seen with the gated SRA arrangement. Staggered arrangements resulted in poorer performance even with the additional contributions of radar. There was no support for the expectation that low densities of SRAs are made sufficient by radar.

A number of experiments have been done investigating the use of electronic navigation systems in restricted waterways (Smith, 1992; Smith and Mandler, 1992; Gynther and Smith, 1989; Smith, Marino, and Multer, 1985; Cooper, Marino, and Bertsche, 1981a, Cooper, Marino, and Bertsche, 1981b). A summary of all of these is beyond the scope of the present Manual, but some overall conclusions are relevant here.

♦ A variety of positioning accuracies and display types showed adequate or even superior performance in the recovery and trackkeeping regions under a variety of visibilities. The observed performance is very similar to that observed with visual ranges, offering support for the use of such technologies when ranges are desirable but not practical.

♦ The turn maneuver sets the limit for the use of any particular electronic system. Good performance through severe turns requires good positioning accuracies, sophisticated displays, some visibility, and/or practiced pilots.

5.2.5 The Last Word on Risk Management

William D. Ruckelshaus, former Administrator of the U.S. Environmental Protection Agency, has the last word on risk management: "Although there is an objective way to manage it, nor can we ignore the subjective perception of risk in the ultimate management of a particular [risk]. To do so would be to place too much credence in our objective data and ignore the possibility that occasionally one's intuition is right. No amount of data is a substitute for judgment."

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APPENDIX A
AUTOMATED RELATIVE RISK FACTOR COMPUTATION PROGRAM
HELP SCREENS

Automated Relative Risk Factor Computation Program

Current Waterway : MIAMI
Help for "Insert/Delete/Add Regions" Form

This form is accessed through the "Use an Existing Waterway" submenu. It allows the user to Insert/Delete/Add regions as described below.

Insert: Use [NEXT/PREVIOUS PAGE] keys to find the region before which the new region is to be inserted. Check "Insert". Hidden fields will appear and offer the selection of a turn, recovery, or trackkeeping region. Check type, check "Execute the operation?," and press [GO]. Data entry forms for region type will appear, labeled "New".

Delete: Use [NEXT/PREVIOUS PAGE] keys to find the region to be deleted. Check "delete", "Execute the operation?" and press [GO]. Region will be deleted.

Add: Check "Add". Hidden fields will offer choice of a turn, recovery, or trackkeeping region. Check type, check "Execute the operation?", and press [GO]. New region will be added to end of existing waterway.

Design Manual Reference: Section 3.3.7

Press any key to continue

Automated Relative Risk Factor Computation Program

Current Waterway : MIAMI

Help for the Trackkeeping Region, SRA Arrangements: NonConforming:

(Note that nonconforming arrangements will result in higher RRF values).

- o gated, short-spaced, nonconforming
- o gated, longer-spaced, nonconforming
- o staggered, short-spaced, nonconforming
- o staggered, longer-spaced, nonconforming
- o one-sided, longer-spaced, nonconforming

Design Manual Reference : Section 4.4

Press any key to continue

Automated Relative Risk Factor Computation Program

Current Waterway : MIAMI

Help for the Trackkeeping Region, SRA Arrangements: Conforming:

o gated, short spaced

-----|-----|-----

-----|-----|-----

< 0.80nm >

o staggered, short spaced

-----|-----

-----|-----|-----

< 0.62nm >

o one sided

-----|-----|-----

< 0.90nm >

o gated, long spaced

-----|-----|-----

-----|-----|-----

< 1.25nm >

o staggered, long spaced

-----|-----

-----|-----|-----

< 1.25nm >

Design Manual Reference:
Section 4.4

Press any key to continue

Automated Relative Risk Factor Computation Program

Current Waterway : MIAMI

Help for the Recovery Region, SRA Arrangements: NonConforming:

(Note that nonconforming arrangements will result in higher RRF values).

- o gated, short-spaced, nonconforming
- o gated, longer-spaced, nonconforming
- o staggered, short-spaced, nonconforming
- o staggered, longer-spaced, nonconforming
- o one-sided, longer-spaced, nonconforming

Design Manual Reference : Section 4.3

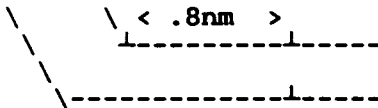
Press any key to continue

Automated Relative Risk Factor Computation Program

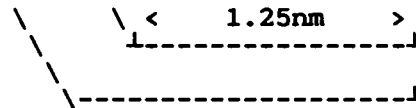
Current Waterway : MIAMI

Help for the Recovery Region, SRA Arrangements: Conforming:

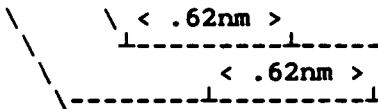
o gated, short spaced



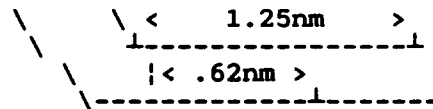
o gated, long spaced



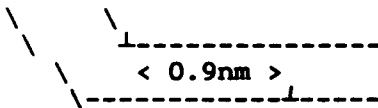
o staggered, short spaced



o staggered, long spaced



o one sided



Design Manual Reference:
Section 4.3

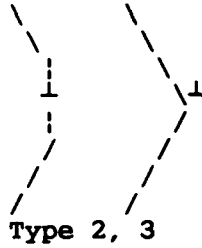
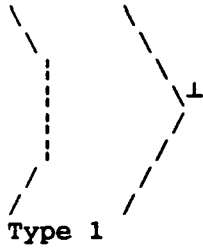
Press any key to continue

Automated Relative Risk Factor Computation Program

Current Waterway : MIAMI

Turn Region Form Help

SRA Arrangements for Cutoff/NonConforming. Examples:
(Note that nonconforming arrangements will result in higher RRF values.)



Design Manual Reference : Sections 4.2

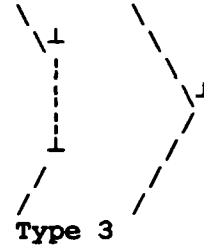
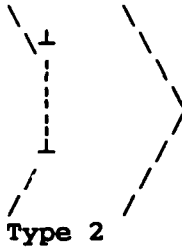
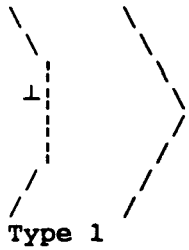
Press any key to continue

Automated Relative Risk Factor Computation Program

Current Waterway : MIAMI

Turn Region Form Help

SRA Arrangements for Cutoff/Conforming. Examples:



Design Manual Reference : Section 4.2

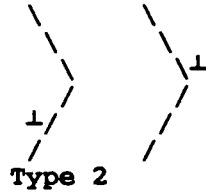
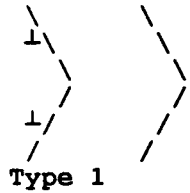
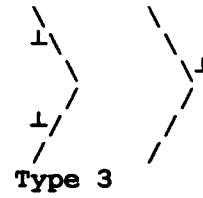
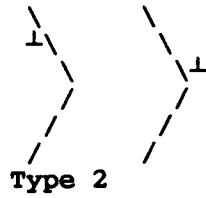
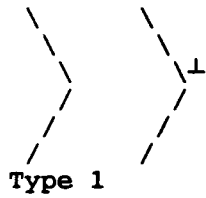
Press any key to continue

Automated Relative Risk Factor Computation Program

Current Waterway : MIAMI

Turn Region Form Help

SRA Arrangements for NonCutoff/NonConforming. Examples:
(Note that nonconforming arrangements will result in higher RRF values).



Design Manual Reference : Section 4.2

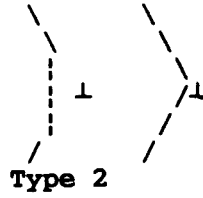
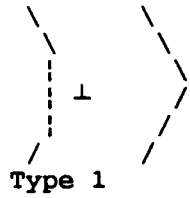
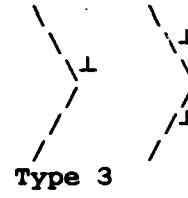
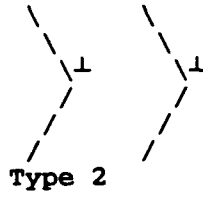
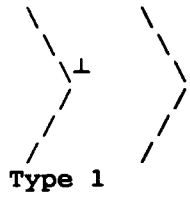
Press any key to continue

Automated Relative Risk Factor Computation Program

Current Waterway : MIAMI

Turn Region Form Help

SRA Arrangements for NonCutoff/Conforming. Examples:



Design Manual Reference : Section 4.2

Press any key to continue

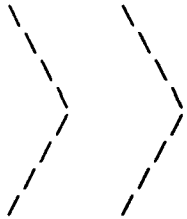
Automated Relative Risk Factor Computation Program

Current Waterway : MIAMI

Turn Region Form Help

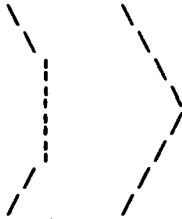
Turn Configurations:

NonCutoff:



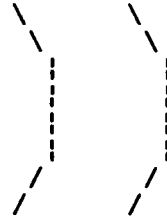
Navigable Width

Cutoff:



Straight Segment Width

Bend:



Navigable Width

Cutoff Turn Extra Width = (Width 2 ship lengths beyond turn apex) MINUS
(straight segment width)

Design Manual Reference : Sections 4.2

Press any key to continue

Automated Relative Risk Factor Computation Program

Current Waterway : MIAMI

Height of eye in feet (ft) is the height of the shiphandler's eye from the surface of the water. (Required if range sensitivity is to be calculated).

Transit Speed in knots (kts) is the speed required in the waterway or that reported by local pilots.

Optional Parameters: (if not entered, these will be estimated by the software from the Required Parameters)

Tactical Diameter (osl) is the tactical diameter in ownship lengths. It is taken from a 35 degree turning circle and divided by the ship length expressed in the same dimension.

Nomoto Par. K* (-) is an index of turning ability calculated from a 20/20 zigzag maneuver and nondimensionalized by ship length.

Nomoto Par. T* (-) is an index of quickness of response to steering calculated from a 20/20 zigzag maneuver and nondimensionalized by ship length.

Design Manual Reference : Sections 3.3.3, 4.1

Press any key to continue

Automated Relative Risk Factor Computation Program

Current Waterway : MIAMI

Help for "Design Vessel Parameters" Form

Use [NEXT PAGE] to toggle between default ship and blank form. The form saved by [GO] will be used in calculations.

Required Parameters:

Displacement in long tons (tons) is the weight of the water displaced by the fully-loaded vessel. This will be estimated from the Ship Size if zero is entered.

Ship size in deadweight tons (dwt) is the capacity of a vessel, or the difference between loaded and light displacement. This will be estimated from the Displacement if zero is entered.

Length in feet (ft) is the vessel's length between perpendiculars (LPB). For a commercial ship, LPB = 0.95 times Length over-all.

Beam in feet (ft) is the width of the vessel at its molded beam, or widest point.

Draft in feet (ft) is the loaded draft (corresponding to the loaded displacement).

Press any key to continue

Automated Relative Risk Factor Computation Program

Current Waterway : MIAMI

Help for "Create/Select Waterway File" Form

If accessed from the "Create a New Waterway" submenu, the form will be available to create a new waterway. This new file will automatically be assigned the name "NewFile" and this name must be changed by the user to enable storage of the file. Chart number and description are optional. Press [NEXT/PREVIOUS PAGE] keys to change current waterway if accessed through "Select". Press [GO] to save selection and return to submenu.

This form may also be used to make a copy of a waterway. To accomplish this, the user must first select the "Create/Select a Waterway File" form. Next, the user should press the [NEXT PAGE] key as necessary, to step through the existing waterway files to choose the one to be copied. When the to-be-copied waterway file is located, the user should change both the original Waterway Name and File Name to new names and press the [GO] key. The user will then be able to modify the copy (new file) and retain the original.

To delete, select the waterway file to be deleted by using [NEXT/PREVIOUS PAGE] keys. Move cursor (up) to bottom of screen to: "Delete the current Waterway?": N." Enter "Y" and [RETURN]. "Are you sure?": N." Enter "Y" and [RETURN] and [GO]. Waterway will be deleted.

Design Manual Reference : Section 3.3.2

Press any key to continue

Automated Relative Risk Factor Computation Program

Current Waterway : MIAMI

Configure Form Help

The user may choose whether printed output is to be directed to a file or a printer; both cannot be selected at the same time.

The next entries allow the user to specify the file name for various outputs to file. When data is printed to these files, old data is overwritten.

The program will not trap errors in printer name. Use system commands to determine if printer name exists.

The data path specified will be the volume and directory where waterways will be saved. The path must exist before it is specified, and the volume must be mounted. Non-existent paths or un-mounted volumes will cause an error message to appear and a rejection of the entry.

Design Manual Reference : Section 3.2.2.4

Press any key to continue

Automated Relative Risk Factor Computation Program

Help for the "Use an Existing Waterway" Menu

This is a secondary system menu. An item is selected by using the cursor keys, and executed by pressing [GO]. The choices available from this menu are:

"Select Existing Waterway Data File": Allows the user to select a Waterway data file for review and/or revision.

"Modify Design Vessel Parameters": Allows the user to inspect or revise.

"Modify a Turn, Recovery, Trackkeeping Region": Allows the user to select a region for review or revision or to add additional regions.

"Insert/Delete/Add Waterway Regions": Allows the user to select a region, and either insert a new region before it, delete it, or add a new region at end.

"Return to Main Menu": Selects the main System menu.

Design Manual Reference: Section 3.2.2.2

Press any key to continue

Automated Relative Risk Factor Computation Program

Help for the "Create a New Waterway" Menu

This is a secondary system menu. An item is selected by using the cursor keys, and executed by pressing [GO]. The choices available from this menu are:

"Create a New Waterway File": Allows the user to specify a new Waterway data file and enter general data.

"Specify Design Vessel Parameters": Allows the user to inspect or revise the design vessel parameters.

"Create a Turn Region": Allows the user to enter Turn Region data.

"Create a Recovery Region": Allows the user to enter Recovery Region data.

"Create a Trackkeeping Region": Allows the user to enter Trackkeeping data.

"Return to Main Menu": Selects the main System menu.

Design Manual Reference: Section 3.2.2.1

Press any key to continue

Automated Relative Risk Factor Computation Program

Help for "Relative Risk Factor Main Menu"

This is the main system menu. Select by using the cursor keys or [RETURN] and execute by pressing [GO]. The choices available from this menu are:

"Create a New Waterway": Allows the user to define a new waterway, and enter the initial Vessel, Turn, Recovery, and Trackkeeping Regions data.

"Use an Existing Waterway": Allows the user to select an existing waterway, and either review or revise the Region data it contains.

"Print Program Report": Allows the user to print Waterway data report.

"Configure Program": Allows the user to specify default output (printer, file) locations, as well as the default data path.

"Quit": Exits the ARRF program.

Design Manual Reference: Section 3.2.1

Press any key to continue

APPENDIX B

AUTOMATED RELATIVE RISK FACTOR COMPUTATION PROGRAM

SAMPLE WATERWAY REPORT

Waterway : MIAMI
 File Name: miami.wwf
 Comments :

Design Vessel Displ. (tons): 42072.00
 Size (dwt): 33000.00
 Length (ft): 574.00
 Beam (ft): 85.00
 Draft (ft): 37.00
 Ht of Eye(ft): 76.00
 Speed (kts): 9.00

Controllability Indices

Tactical Diameter (osl): 2.83
 Nomoto Par. K* (-): 1.00
 Nomoto Par. T* (-): 2.00

Totem Pole:

Day RRF	Night RRF	Range RRF
> 0.900		T4
0.800		
0.700		R1
0.600 R1	R1	K2
0.500	T4	
0.400 K2	K2 R3	
0.300 T4	R5	R3
0.200 R3 R5		
0.100		
0.090		
0.080		
0.070		
0.060		
0.050		
0.040		
0.030		
0.020		
0.010		
0.009		
0.008		
0.007		
0.006		
0.005		
0.004		
0.003		
0.002		
0.001		
0.000 K6	K6	

Recovery Region Data

Region Code : R1A Description : ENTRANCE FROM SEA
 Navigable width (ft) : 500.00 Max crosstrack current (kts) : 4.00
 SRA configuration:

Day: Gated(S): Gated(L): Staggered(S): Staggered(L): 1-side: X
Night: Gated(S): Gated(L): Staggered(S): Staggered(L): 1-side: X

Day: Conforming? : Y Night: Conforming? : Y

Range Data Sensitivity : 2.36
Separation (yds) : 675.00 Distance (yds): 5000.00
Front height (ft) : 27.00 Rear height (ft) : 49.00

RRF Day: 0.6944 Night: 0.6944 Range: 0.7011 Upgraded Range: 0.3183

Trackkeeping Region Data

Region Code : K2A Description : OUTER BAR CUT

Navigable width (ft) : 500.00 Max crosstrack current (kts) : 4.00

SRA configuration:

Day: Gated(S): X Gated(L): Staggered(S): Staggered(L): 1-side:
Night: Gated(S): X Gated(L): Staggered(S): Staggered(L): 1-side:

Day: Conforming? : Y Night: Conforming? : Y

Range Data Sensitivity : 2.36
Separation (yds) : 675.00 Distance (yds): 5000.00
Front height (ft) : 27.00 Rear height (ft) : 49.00

RRF Day: 0.4310 Night: 0.4310 Range: 0.6496 Upgraded Range: 0.0010

Recovery Region Data

Region Code : R3A Description : TURN 1 EAST

Navigable width (ft) : 500.00 Max crosstrack current (kts) : 4.00

SRA configuration:

Day: Gated(S): X Gated(L): Staggered(S): Staggered(L): 1-side:
Night: Gated(S): X Gated(L): Staggered(S): Staggered(L): 1-side:

Day: Conforming? : Y Night: Conforming? : Y

Range Data Sensitivity : 3.19
Separation (yds) : 675.00 Distance (yds): 3300.00

Front height (ft) : 27.00 Rear height (ft) : 49.00
RRF Day: 0.2991 Night: 0.4521 Range: 0.3183

Turn Region Data

Region Code : T4A Description : TURN 1

Turn configuration (check one)

NonCutoff: Cutoff: X Bend: Extra width (ft) : 500.00

Turn angle (deg) : 45.00 Day: Type (1 - 3) : 3 Conforming? : Y
 Night: Type (1 - 3) : 3 Conforming? : Y

Straight segment width : 500.00 Max crosstrack current (kts) : 3.50

Range Data Sensitivity : 3.83
Separation (yds) : 675.00 Distance (yds): 2500.00
Front height (ft) : 27.00 Rear height (ft) : 49.00

RRF Day: 0.3811 Night: 0.5069 Range: 1.0000

Recovery Region Data

Region Code : R5A Description : TURN 1 WEST

Navigable width (ft) : 500.00 Max crosstrack current (kts) : 3.50

SRA configuration:

Day: Gated(S): X Gated(L): Staggered(S): Staggered(L): 1-side:
Night: Gated(S): X Gated(L): Staggered(S): Staggered(L): 1-side:

Day: Conforming? : Y Night: Conforming? : Y

Range Data Sensitivity :
Separation (yds) : Distance (yds):
Front height (ft) : Rear height (ft) :

RRF Day: 0.2194 Night: 0.3781 Range: Not Ready

Trackkeeping Region Data

Region Code : K6 Description : GOVT CUT

Navigable width (ft) : 400.00 Max crosstrack current (kts) : 0.00

SRA configuration:

Day:	Gated(S): X	Gated(L):	Staggered(S):	Staggered(L):	1-side:
Night:	Gated(S): X	Gated(L):	Staggered(S):	Staggered(L):	1-side:

Day: Conforming? : Y Night: Conforming? : Y

Range Data		Sensitivity :
Separation (yds) :		Distance (yds):
Front height (ft) :		Rear height (ft) :

RRF Day: 0.0000 Night: 0.0000 Range: Not Ready

Recovery Region Configuration Options

Region Code : R1 Region Description : ENTRANCE FROM SEA

Region Width : 500.00 Cross Current : 4.00

	Daytime RRF Values	Nighttime RRF Values
Short Gated	: 0.2991	0.4521
Long Gated	: 0.2991	0.4521
Short Staggered	: 0.4848	0.4848
Long Staggered	: 0.5992	0.5992
One Sided	: 0.6944	0.6944

High Sensitivity Range : 0.3183

Low Sensitivity Range : 0.7011

Trackkeeping Region Configuration Options

Region Code : K2 Region Description : OUTER BAR CUT
Region Width : 500.00 Cross Current : 4.00

Daytime RRF Values		Nighttime RRF Values
Short Gated	: 0.4310	0.4310
Long Gated	: 0.6360	0.6360
Short Staggered	: 0.6020	0.6020
Long Staggered	: 0.6574	0.6574
One Sided	: 0.8642	0.8642

High Sensitivity Range : 0.0010
Low Sensitivity Range : 0.6496

Recovery Region Configuration Options

Region Code : R3 Region Description : TURN 1 EAST
Region Width : 500.00 Cross Current : 4.00

Daytime RRF Values		Nighttime RRF Values
Short Gated	: 0.2991	0.4521
Long Gated	: 0.2991	0.4521
Short Staggered	: 0.4848	0.4848
Long Staggered	: 0.5992	0.5992
One Sided	: 0.6944	0.6944

High Sensitivity Range : 0.3183
Low Sensitivity Range : 0.7011

Turn Region Configuration Options

Region Code : T4 Region Description : TURN 1
Region Width : 500.00 Cross Current : 3.50 Turn Angle : 45.00
Turn Type : Cutoff Extra Width : 500.00

Daytime RRF Values	Nighttime RRF Values
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Type One	: 0.7966	0.7651
Type Two	: 0.3811	0.5069
Type Three	: 0.3811	0.5069

High Sensitivity Range : 1.0000
Low Sensitivity Range : 1.0000

Recovery Region Configuration Options

Region Code : R5 Region Description : TURN 1 WEST
Region Width : 500.00 Cross Current : 3.50

	Daytime RRF Values	Nighttime RRF Values
Short Gated	: 0.2194	0.3781
Long Gated	: 0.2194	0.3781
Short Staggered	: 0.4101	0.4101
Long Staggered	: 0.5381	0.5381
One Sided	: 0.6400	0.6400

High Sensitivity Range : 0.2504
Low Sensitivity Range : 0.6607

Trackkeeping Region Configuration Options

Region Code : K6 Region Description : GOVT CUT
Region Width : 400.00 Cross Current : 0.00

	Daytime RRF Values	Nighttime RRF Values
Short Gated	: 0.0000	0.0000
Long Gated	: 0.0000	0.0000
Short Staggered	: 0.0000	0.0000
Long Staggered	: 0.0000	0.0000

One Sided : 0.0003

0.0003

High Sensitivity Range : 0.0000

Low Sensitivity Range : 0.0000