8-11.I

REPORT NO. CG-D-55-78

OFFSHORE VESSEL TRAFFIC MANAGEMENT (OVTM) STUDY
Volume I -- Executive Summary

U.S. DEPARTMENT OF TRANSPORTATION
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION
Transportation Systems Center
Cambridge MA 02142

AUGUST 1978

FINAL REPORT

DOCUMENT IS AVAILABLE TO THE U.S. PUBLIC
THROUGH THE NATIONAL TECHNICAL
INFORMATION SERVICE, SPRINGFIELD,
VIRGINIA 22161

Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD
Office of Marine Environment and Systems
Washington DC 20590

NOTICE

This technical study examines traffic management alternatives as a means to reduce or eliminate casualties contributing to pollution of the marine environment. Nothing contained in this report should be construed as affecting or changing the Administration's position on offshore claims in general or at the Third United Nations Conference on the Law of the Sea in particular.

NOTICE

This document is disseminated under the sponsorship of the U.S. Department of Transportation in the interest of information exchange. The United States Government assumes no liability for its contents or use thereof.

NOTICE

The United States Government does not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the objectives of this report.

Technical Report Documentation Page

1. Report No. CG-D-55-78	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle OFFSHORE VESSEL TRAFFIC MANAGEMENT (OVTM) STUDY Volume I - Executive Summary		5. Report Date August 1978
		6. Performing Organization Code
7. Author(s) R. Bland, R. Kalafus, R. Wisleder, et al.*		8. Performing Organization Report No. DOT-TSC-CG-78-11,I
9. Performing Organization Name and Address U.S. Department of Transportation Research and Special Programs Administration Transportation Systems Center Cambridge MA 02142		10. Work Unit No. (TRAIS) CG816/R8007
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address U. S. Department of Transportation United States Coast Guard Office of Marine Environment and Systems Washington DC 20590		13. Type of Report and Period Covered Final Report Aug. 1977 to June 1978
		14. Sponsoring Agency Code

15. Supplementary Notes

*F. Frankel, D. Prerau, S. Protopapa, D. Glater, J. LoVecchio, and R. Wiseman

16. Abstract

The objectives of the study were: (1) to analyze the causes of tanker and other vessel casualties that could potentially result in oil pollution, and (2) to evaluate various alternative vessel traffic management systems and techniques for the prevention of oil-polluting casualties in the U.S. offshore waters. The geographical areas of interest are the waters from the U.S. coast out to 200 NM around the contiguous 48 states, Hawaii, Puerto Rico, the Virgin Islands and Alaska, except the area north of the Aleutian Islands. Three types of casualties are addressed in the study: groundings, collisions, and rammings. Vessels included in the study are tank vessels (tankers and tank-barges) over 1,000 gross tons.

The analysis of the causes of tank vessel casualties is performed mainly with the Coast Guard Merchant Vessel Casualty Report (MVCR) data base covering the period from July 1971 to October 1977. Other data sources surveyed include: the Lloyd's Weekly Casualty Reports, the Tanker Casualty Library of Marine Management Systems, Inc., and the Coast Guard Pollution Incident Reporting System. The nature and characteristics of tank vessel casualties that occur in the U.S. offshore waters are described. Systems and techniques considered as alternatives for preventing these casualties are identified, evaluated against each casualty and given an overall rating of casualty prevention effectiveness based on criteria which are defined. The promising systems are selected and conceptual descriptions are presented including the operational features, technical description, cost, staffing and training required, and legal implementation considerations.

The report is organized in three volumes: Volume I -- Executive Summary, Volume II -- Technical Analyses, and Volume III -- Appendixes.

17. Key Words Vessel Traffic Management, Tanker, Tank-Barge, Oil Pollution, Oil Imports, Vessel Collisions, Groundings, Strandings, Argo Merchant, Oil Spills, Rammings	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 36	22. Price

Form DOT F 1700.7 (8-72)   Reproduction of completed page authorized

PREFACE

The Offshore Vessel Traffic Management (OVTM) Study was performed in response to Presidential Initiatives issued in March 1977 which were a result of the Argo Merchant oil spill and several other tanker casualties that occurred in the U.S. offshore waters during the winter of 1976-77. These initiatives called for the Secretary, U.S. Department of Transportation, to perform several studies and take other actions to prevent or reduce the effects of oil spills from tank vessel casualties in the U.S. offshore waters. The OVTM Study was referred to in the Presidential Initiatives as "a study of long range vessel surveillance and control systems." The Transportation Systems Center performed this work in support of the U.S. Coast Guard and the Office of the Secretary of Transportation. The study effort was initiated in August 1977 and completed in June 1978.

This study was directed by the Coast Guard Port Safety and Law Enforcement Division with specific guidance by the following individuals: CAPT Richard A. Bauman, USCG; CDR Eugene J. Hickey, USCG; Mr. Don Ryan, and LCDR John Bannan, USCG. Special recognition is given to the Coast Guard Project Manager, Don Ryan, for his many helpful contributions to, and close association with, the TSC study team. Other contributors were: CAPT (Ret. USCG) Harold Lynch, CAPT Arthur Knight and CAPT William Mitchell, all of the Boston Marine Society; John Devanney of the Massachusetts Institute of Technology Center for Transportation Studies; and Patricia Concannon and Jeanette Collier of TSC.

1. INTRODUCTION

The purpose of the Offshore Vessel Traffic Management (OVTM) study is to determine the measures which offer some promise of reducing the occurrence of oil tanker and tank-barge casualties in waters offshore of the United States. The need for improvements in marine safety to prevent oil pollution of the U.S. offshore waters was highlighted by a series of tank vessel casualties in the winter of 1976-77 which included the grounding and total loss of the fully loaded Argo Merchant off the East coast. This rash of tank vessel oil spills together with the continuing growth in oil imports to the United States prompted the President to issue several Presidential Initiatives in March 1977 to the Secretaries of the U.S. Departments of Transportation and Commerce to perform studies and take actions necessary to prevent them.

This study addresses the causes of and alternative measures for prevention of three types of tanker casualties: (a) groundings (including strandings), (b) collisions between vessels, and (c) rammings of offshore oil platforms and aids-to-navigation. The vessels of interest include tankers and tank-barges larger than 1,000 gross tons. The geographical area of interest includes the waters from the U.S. coast out to 200 NM around the contiguous 48 states, Puerto Rico, the Virgin Islands, Hawaii, and Alaska except the area north of the Aleutian Islands. Excluded from the study are all ports, harbors, inland waters, and offshore channels that are less than 1,000 feet wide.

An estimated 121 casualties pertinent to this study occurred during the 6-year study period, July 1971 through September 1977. Seventy-eight cases, which were documented with detailed casualty investigation reports, were analyzed for causal determination and assessment of system alternatives.

o The majority (over 90 percent) of offshore casualties occur within 50 NM of the shore; the greatest distance from shore of any casualty studied is 108 NM. Therefore, there is little justification for any system to provide surveillance coverage out to 200 NM.

o Traffic density is not a factor in the large majority of casualties. It is rare that a collision involves a third independent vessel. In 90 percent of the groundings only the vessel that grounded is involved in the events leading to the incident. The rammings (of oil platforms) have involved only the vessel which rammed the oil platform.

o The major causes of groundings are: (1) lack of attention to and misjudgment of the vessel's location and movement relative to the water depth, (2) lack of vigilance by the crew in using <u>all</u> available navigation information, (3) inadequate pilot boarding procedures for deep draft vessels, (4) lack of knowledge of the presence of submerged objects and shoals, (5) poor navigation/ maneuvering practice, and (6) inoperable or malfunctioning navigation equipment.

o The major causes of collisions are: (1) failure to establish vessel-to-vessel communications and to agree on a plan for passing, (2) poor seamanship, or what may be called a lack of "defensive sailing," especially under conditions of poor visibility, (3) lack of timely assessment of the imminent danger of collision, and (4) poor execution of an agreed upon or standard passing maneuver.

o The major causes of rammings (of offshore oil platforms) are: (1) failure to maintain proper lookout, (2) poor navigation practice: failure to use all navigation information available on the vessel to determine the vessel's position, and (3) error in judgment or lack of attention by the conning officer in maneuvering the vessel.

o Tugs with barges used in the transport of oil represent an important oil pollution risk. There are many of these vessels carrying large quantities (over 100,000 gallons) of oil or petroleum products, with some traveling long distances; e.g., from the Gulf of Mexico to the northeastern U.S. ports. These vessels

3. RECOMMENDATIONS

The recommendations resulting from the study are:

o Implement a rule requiring all seagoing petroleum carrying vessels over 300 gross tons to be equipped with LORAN-C, or an equivalent navigation aid.

o Install RACONs on carefully selected buoys or towers to identify positively the entrance to harbors, traffic lanes, and fairways, and other hazardous, frequently traveled offshore areas; example locations are the approaches to Delaware and Chesapeake Bays, and fairway intersections in the Gulf of Mexico.

o Perform a study of pilotage practices in Delaware and Guayanilla Bays. Over 40 percent of all groundings analyzed in the study have occurred in these two bays.

o Assess the costs and benefits of providing LORAN-C coverage for the Puerto Rico and Virgin Islands area. This aid-to-navigation would likely have prevented one grounding and possibly have prevented three others.

o Upgrade the requirements for licensing, license renewal, and training of masters and officers of tank vessels to include periodic tests and demonstrations of proficiency (approximately every five years) in the navigation of deep draft vessels, in the use and operation of all navigation aids, and in the knowledge of regulations and rules of the road.

o Implement the "vessel passport" system described in Section 7. The costs to the user and the Government are low if existing communications systems are used. This is a "core" system, and is expandable as the need for it develops. In approximately three years, a study should be made to assess the needs, benefits, and costs of upgrading the capability of the "vessel passport" system.

o Conduct a design and feasibility demonstration study of a low cost transponder system. The projected cost of a proposed VHF/transponder system appears to be reasonable, but a design

4. STUDY APPROACH

The study approach focuses on analyzing actual casualty reports of tank vessel incidents to determine the causes of groundings, collisions, and rammings, and on using this causal information to develop alternative systems and techniques for their prevention. A flow chart of the study tasks is shown below.

The primary source of data used in the casualty analysis is the U.S. Coast Guard Merchant Vessel Casualty Report (MVCR) data base covering the period from July 1971 through September 1977. This data base includes detailed casualty reports from the vessel master and U.S. Coast Guard investigator. Additional data have been obtained from the Lloyd's Weekly Casualty Reports.

The total number of groundings, collisions and rammings that have occurred in U.S. offshore waters during the 6-year study period is estimated at 121.* From the detailed casualty records in the MVCR data base, the following 63 tank vessel cases are available for detailed analysis: 47 groundings, 10 collisions, and 6 rammings. However, 15 additional casualties involving non-tank vessels over 5,000 gross tons have been used in the analysis of causative factors; i.e., 8 groundings, 7 collisions, and 0 rammings. The total data base for causal analysis is 78 incidents.

Statistical analysis techniques are not suitable for a data sample of this small size; therefore, each case has been examined in detail for causative factors and assessment of alternative systems.

Early in the study, about 30 systems** were identified as holding some potential for reducing casualties. These systems

---

*An exact count of the casualties that have occurred in the U.S. offshore waters out to 200 NM during the study period is impossible since the U.S. Coast Guard casualty file does not usually include foreign-flag casualties outside of 3 NM, and Lloyd's Reports often lack detailed information on casualty location.

**A system is defined as any combination of rules, procedures, equipment hardware/software, and operating personnel.

range from simple operating procedures to complex surveillance techniques. From these systems, 34 operational features* are extracted which pinpoint the system elements that are operationally useful in preventing casualties. Each operational feature is evaluated against each casualty in the data base to determine the most useful features. From the results of this assessment, 18 promising systems have been identified, and subjected to a thorough evaluation. They are evaluated not only on their usefulness and effectiveness in preventing casualties, but also on their costs, geographic coverage, operational ease, user acceptance, reliability, state of development, implementability, and Government action required.

Evaluating the 18 systems against the data base casualties does not account for the preventive measures which will soon be in effect, and which will substantially reduce casualties without other systems being implemented. Therefore, a Baseline System has been defined to provide a reference point for the evaluation of the various systems. The effectiveness of other systems is measured by the extent to which casualties will be prevented beyond those prevented by the Baseline System which has an effectiveness of 23 percent. The Baseline System includes all currently required equipment, rules, and procedures plus dual radars on board vessels over 10,000 gross tons, and LORAN-C, or equivalent navigation equipment, on board vessels over 1,600 gross tons.

*An operational feature is defined as an element of a system. A system may consist of one or more operational features, some of which are included in several systems. Also, some operational features are independent (they stand alone), while others are dependent on other features to perform their functions.

o Worldwide oil spill statistics indicate that an average of 3 to 4 spills greater than 6-million gallons have occurred per year over the 8-year period of 1969 to 1976.

o The damage caused by an oil spill varies greatly depending on the type of petroleum, the weather and sea conditions, and the location of the casualty relative to beaches and fishing areas. For example, studies performed on the Argo Merchant spill of 7.5-million gallons of crude oil in the middle of the rich Georges Bank fishing area off the Massachusetts coast have found no measurable damage to either the fish/marine population or the nearby shore. The wind and wave motion in this instance has pushed the oil spill farther out to sea where it has dispersed.

o As indicated in the table above, groundings present a greater threat of oil spillage in offshore waters than collisions and rammings. Also, groundings usually cause more pollution and environmental damage because a higher percentage of them occur near shore (see Section 5.2).

5.2 CHARACTERISTICS OF CASUALTIES

The casualty analysis has resulted in the identification of a number of important characteristics which help provide a general understanding of groundings, collisions, and rammings offshore.

o Vessel Size: Tankers involved in casualties in U.S. offshore waters are usually under 75,000 gross tons, and tank-barges generally below 5,000 gross tons.

o Vessel Types: The percentage of offshore tank vessel collisions involving tankers is about equal to that involving tank-barges. On the other hand, tankers are involved in 90 percent of the data base groundings.

o Vessel Flag: All tank-barges listed in the casualty file are of U.S. registry, as is expected, since the presence of foreign-flag tank-barges is rare in the area under study. Analysis of tanker casualties in U.S. offshore waters reported in Lloyd's Weekly Casualty Reports reveals a 1:3 ratio between U.S. and

5.3 FACTORS AND CAUSES OF CASUALTIES

The factors and causes of the 78 casualties subjected to causative analysis are summarized below.

- In general, the causes of the casualties are related to human errors rather than problems caused by faulty equipment.

- In the case of groundings, the most common causative factor is navigational error (i.e., wrong position) which occurs in 72 percent of the casualties. In 38 percent of the cases, poor navigation practice is involved. Other factors are conning errors (i.e., poor judgment in maneuvering) in 18 percent of the cases; and errors in not waiting for a pilot, or waiting in an unsafe area, in 13 percent. Some of these groundings involve more than one of these major factors.

- The major factor in collisions is a lack of agreement in the passing maneuver, which occurs in 41 percent of the casualties. Other factors are one vessel not knowing the location of the other (in 24 percent), and poor performance of standard passing procedures (in 18 percent of the cases).

- The leading causative factor in rammings is failure to maintain proper lookout on the vessel, which has been found in 50 percent of these casualties. Other factors are conning errors (in 33 percent), and navigational errors (in 17 percent).

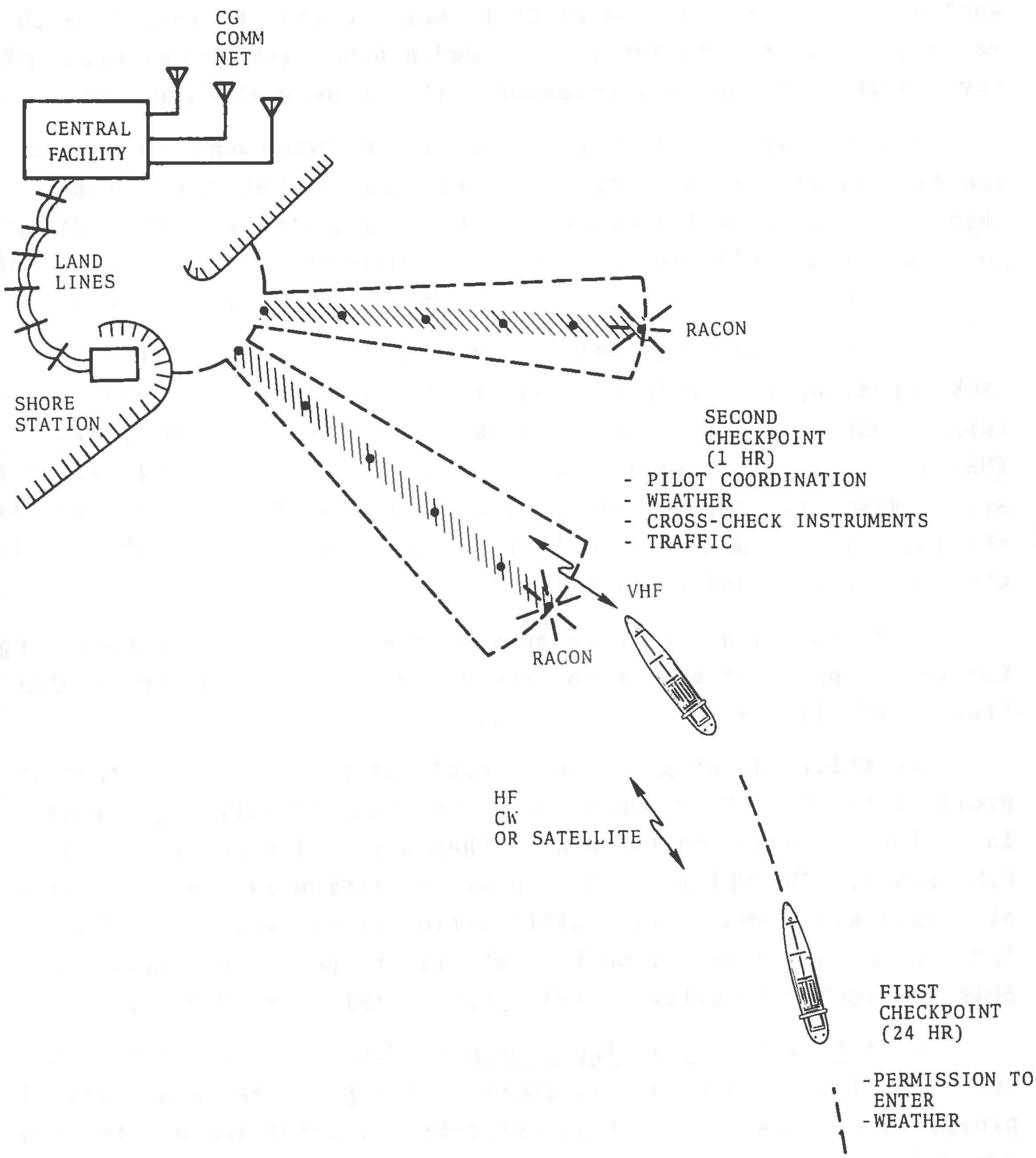
Adjustments are then made to account for changes and safety improvements which are expected to be in effect during the future period, independent of techniques presently under evaluation. Specifically, it is assumed that: (1) the Baseline System will be 40 percent in effect by 1980 and 100 percent by 1985, and (2) the casualties per trip of tankers engaged in Alaskan oil trade will be one-half that of the base period average, due to the superior condition of these vessels, the existence of Vessel Traffic Services in Valdez, Puget Sound, and San Francisco, and other independent safeguards in effect.

After making these adjustments, the number of tank vessel casualties likely to occur in U.S. offshore waters during the 1981-1990 period is projected as follows: 196 groundings, 65 collisions, and 10 rammings. Of course, the implementation of any independent improvements in marine safety, not foreseen or evaluated in this study, can be expected to reduce these casualty projections to some extent.

SUMMARY OF PROMISING SYSTEMS

SYSTEM	NET EFFECTIVENESS* (PERCENT)	TOTAL VESSEL COSTS** (MILLION $)	TOTAL GOVERNMENT COSTS** (MILLION $)	TOTAL SYSTEM COSTS** (MILLION $)
1. Baseline	0*	0	0	0
1A. Extended Baseline***	6	0	19.2	19.2
2. Passport System	40	0	9.5	9.5
3. Auto Monitoring	67	18.8	35.2	54.0
4. DF Surveillance	40	0	20.5	20.5
5. Radar Surveillance	57	0	36.2	36.2
6. Satellite Surveillance	65	223.5	84.5	308.0
7. Training	6	37.8	0	37.8
8. Traffic Separation	5	0	0	0
9. Aids-to-Navigation	14	0	0.5	0.5
10. Pilotage	18	0	0	0
11. Equipment Standards	3	0	0	0
12. Navigation Alert	8	15.7	0	15.7
13. Depth Alert	11	6.2	0.5	6.7
14. Scanning Sounder	5	43.0	1.3	44.3
15. Collision Avoidance Aid	5	215.1	0	215.1
16. Radar Perimeter Det.	6	7.7	0	7.7
17. VHF/Transponder	13	28.9	0.9	29.8
18. Interrogator/ Transponder	3	66.5	0	66.5

*Net effectiveness is over and above the Baseline which has an effectiveness of 23 percent.
**Net present value through 1990.
***Extended Baseline consists of extending LORAN-C coverage to Puerto Rico and the Virgin Islands.



VESSEL PASSPORT SYSTEM

grounding alerts. A data/voice communications set, which interfaces with the electronic navigation instruments, gyro compass, and ship's log, is required on board all commercial vessels. The communications set provides the shore station with automatic updates of position, course, and speed. No action is required of the vessel master other than turning on the equipment. The shore station keeps track of all vessels, and plots courses and projected positions using data/voice communications equipment, computers, and computer driven displays.

4. Direction Finding (DF) Surveillance System -- Rather than being a separate system, DF surveillance is a capability which can be added to the passport or automatic monitoring systems. It utilizes two DF stations at each port to determine the position of vessels operating within 20 NM of the port. When the VHF transmitter on board a vessel is turned on, two bearings are established by the DF stations which the shore operator can plot to determine position. (This procedure can be automated.)

This system has the advantage of providing an inexpensive way of checking a vessel's position from shore. It is somewhat limited in range and accuracy.

5. Radar Surveillance -- Radar provides the shore operator with a plan-position-indicator (PPI) display of vessels, buoys, and terrain features within the range of the radar, with a refresh rate of about once every four seconds. It requires no equipment on board the vessel, but does not provide identification of targets.* Due to its cost and limited range (20-40 NM), it is not a viable candidate to provide wide surveillance coverage, and is considered only as a backup to a vessel passport system near ports that have special needs justifying its use.

6. Satellite Surveillance -- Satellite systems offer high accuracy and nearly global coverage. In a typical system, a shore station sends an interrogation signal, selectively addressed and including a time identifier, to a master satellite, which

*However, if compatible transponders become required equipment in the future, they can provide vessel identification.

of Engineers and adoption by IMCO.

9. Improved Aids-To-Navigation -- The present system of aids-to-navigation, maintained by the U.S. Coast Guard, is probably the most comprehensive of its kind in the world. Specific areas for improvement have been identified in the study, notably in buoy identification, buoy location and monitoring, and the need for more RACONs. Such improvements will benefit the prudent mariner, but without measures to ensure their use, cannot by themselves guarantee a reduction in casualties.

10. Pilot Transfer Procedure System -- The present procedures by which a pilot is contacted and a time and location arranged for pilot boarding has serious shortcomings in a few areas. The system of rules and procedures needs to be strengthened, at least for tank vessels, to limit their entry to specified safety zones until a pilot has boarded. The main problem is that each port has unique ocean bottom topographies, and unique traditions, making it difficult to formulate National standards. In addition, most such pilotage requirements are established under state, rather than Federal, authority.

11. Improved Equipment Standards -- A system that incorporates improved equipment standards essentially adopts the practices of a prudent vessel owner, and tries to enforce them on all vessels bound for or departing from a U.S. port. These practices include: purchase of equipment meeting a recognized standard, maintaining a comprehensive spare-parts supply, preventive maintenance, and one member of the crew capable of making at least simple repairs. The first two measures can be readily established by occasional inspections. The third and fourth are easily avoided by any vessel owner trying to cut costs.

12. Processor-Aided Navigation Alert System -- With improvements in performance, cost, and reliability of microprocessors and other digital circuitry, it is now possible to automate and integrate several bridge functions reliably and relatively inexpensively. For example, deviation from preselected tracks can be

15. <u>Collision Avoidance Aid</u> -- Collision avoidance aids are presently available commercially. They process radar data, identify targets, track vessels and other targets, project future vessel courses on a display, and provide a warning in case of a predicted collision. Automatic acquisition of targets is crucial to their effectiveness in offshore waters; however, not all collision avoidance aids have this capability. They are quite effective, but are slow to adjust to frequent maneuvers of other vessels. Their expense limits them to use on large vessels. This reduces their availability, and thus reduces their net effectiveness as a general countermeasure to collisions.

16. <u>Radar Perimeter Detection Device</u> -- The radar perimeter detection device is an adjunct to a standard on-board radar, and is designed to be a low-cost, limited capability, collision avoidance aid. It is based on the concept of guard zones, or circles with own vessel at the center. If a radar target appears within a guard zone, an alarm sounds, alerting the vessel watchstander to the presence of an echo. A particularly useful design incorporates outer and inner guard zones, each independently defined and adjustable by the operator. It does not track targets or project courses, but merely alerts the bridge of a nearby target. It is quite inexpensive, but requires the watchstander to interpret and assess the situation manually. It is also susceptible to saturation and false alarms by clutter and land echoes.

17. <u>VHF/Transponder System</u> -- The VHF/transponder system is an anti-collision concept developed at TSC to provide an inexpensive alternative to the interrogator/transponder system described below. It consists of a simple VHF code transmitter/receiver and an associated radar transponder. It provides the vessel watchstander with an alert and identification information when another equipped vessel approaches within a few miles. The watchstander can ascertain the corresponding radar target by manually interrogating the identified vessel. The system facilitates bridge-to-bridge communications by providing vessel identification, and can be configured

a clearer picture of the relative merits of Government versus vessel owner expenditures, seven strategies are postulated. The parenthetical numbers refer to the systems described above.

A. No Further Action -- This is the Baseline System (1).

B. High Vessel/Low Government Investment -- This strategy requires Navigation Alerts (12) and VHF/Transponders (17) on all vessels over 1,600 gross tons, Radar Perimeter Detection (16) and Depth Alerts (13) on all tank vessels, and Collision Avoidance Aids (15) and Scanning Depth Sounders (14) on all tankers greater than 10,000 gross tons.

C. Moderate Vessel/Low Government Investment -- This strategy requires Navigation Alerts (12) and VHF/Transponders (17) on all vessels greater then 1,600 gross tons.

D. No Vessel/Moderate Government Investment -- This strategy consists of the implementation of the Vessel Passport system (2).

E. No Vessel/High Government Investment -- This strategy consists of the implementation of Radar Surveillance (5) (without on-board transponders), in addition to the Vessel Passport system (2).

F. Low Vessel/High Government Investment -- This strategy consists of the implementation of Automatic Monitoring (3).

G. High Vessel/High Government Investment -- This strategy consists of the implementation of Satellite Surveillance (6).

The figure below shows the costs (present value) and total casualties prevented for the seven stategies through 1990, and takes into account the time required for implementation. It is apparent from this figure that even with large expenditures in vessel equipment, the total effectiveness of low Government cost strategies (B and C) is less than that of the vessel passport system (D). The figure also shows that for other strategies, increased effectiveness beyond that of the vessel passport system is achieved at progressively higher costs.

The vessel passport system emerges as the clear choice of the various system designs considered. The automatic monitoring system (F), which includes the vessel passport system, achieves a significant increase in effectiveness, but with a reduced effectiveness-to-cost ratio. It can be phased into the vessel passport system at a later date if experience justifies this action. Adoption of either of these systems can be expected to reduce substantially collisions, rammings, and groundings in the offshore waters of the United States. This reduction can be further enhanced by the several independent programs of action recommended in Section 3.

☆U.S. GOVERNMENT PRINTING OFFICE: 1978—700-403/175

850 copies