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RDT&E PLAN FOR MARINE SAFETY

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FINAL REPORT

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16. Abstract

This report presents the results of a study of future research needs in marine safety and environmental protection. Principal output of the study is an RDT&E plan describing work that would provide effective research support for the Coast Guard's marine safety activities. The most significant feature of the plan is that it combines the research needs of all the Coast Guard's organizational subdivisions relating to marine safety and environmental protection into a single, integrated plan of action.

The plan is composed of fourteen project areas, each addressing a major problem in marine safety such as "vessel collisions" or "identification of pollution spills." The project areas are subdivided into projects, and then tasks.

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SUMMARY

In recent years, the U. S. Coast Guard's need for RDT&E support of its missions has become greatly intensified and extremely complex as a result of a number of factors:

- Drastic expansion of USCG mission scope due to the extension of the 200-mile limit, being assigned primary responsibility for protection of the entire marine environment, the expansion of its responsibility with respect to port safety, and the potential addition of vessel classes (such as foreign tankers and fishing) to the list of those for which it already has primary responsibility.

- Proliferating changes in the technology of vessels and ocean-industry systems, such as LNG tankers and high-speed passenger vessels, that are introducing new hazards into marine environment.

- Reduction in the level of experience-based maritime expertise in USCG organizational makeup* that must be supplemented by the conduct of sophisticated research and development endeavors.

These factors have not merely generated new areas in which research efforts are needed to help the Coast Guard carry out its missions. The proliferation of missions coupled with the multifaceted nature of the Coast Guard's organizational makeup have imposed the need for the research efforts to be organized and coordinated to a degree unprecedented in the past. Battelle and the Coast Guard, working in close cooperation, developed, and subsequently refined, an intensively organized, integrated RDT&E plan which encompasses the highly disparate subject areas now represented in the Coast Guard missions. Emphasis was also placed on making the plan as cost effective as possible by eliminating redundant effort and taking full advantage of the synergistic relationships existing among the areas.

The plan, known simply as "The RDT&E Plan for Marine Safety", sets forth the research support requirements of all of the Coast Guard missions having to do with safety in the commercial marine domain. These missions include:

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* The configuration of the Coast Guard's assigned missions in modern times has steadily diluted the total organization's involvement in actual sea-going operations (as opposed to regulatory and administrative activities related to ocean and waterways matters). This has resulted in less experience at sea, on the average, for individual Coast Guardsmen, hence, the reduction in level of experience-based expertise referred to above.

- Commercial Vessel Safety Program - plan review/approval, vessel inspection, personnel licensing and requirements, vessel admeasurement, and vessel documentation.

- Aids to Navigation Program - development, design, placement, and maintenance of both short-range and radio aids to navigation.

- Bridge Administration Program - cognizance of the safety aspects of waterways interfacing with bridges.

- Marine Environmental Protection Program - responsibility for the prevention of polluting spills and their effective cleanup when they do occur.

- Port Safety and Security Program - responsibility for all boarding and regulatory activities ensuring the safety of ports including Vessel Traffic Services.

- Deepwater Ports Project - development of policy and regulations to establish an acceptable level of safety in connection with the design and functioning of offshore ports.

- Ports and Waterways Planning - determination of policies and plans regarding marine safety and other matters as a basis for long-range planning.

The programmatic content of the plan is designed to support all of these missions without redundancy among its tasks, projects, and project areas. This economy and directness in the structure of the plan was achieved through a plan development process directed to exploiting to the full, the Coast Guard management's experience and expertise in the technologies of the different mission areas and carried out in an integrated organizational setting.

Development of the RDT&E Plan

The plan was developed as a result of carrying out a five-step procedure involving close collaboration between the study team and selected Coast Guard representatives from the program offices and administrative elements at Headquarters:

(1) Review, by the study team, of documented history and present plans for RDT&E.

(2) Conduct of a series of seminars on research-support needs pertaining to each of the programs and program functions considered individually.

(3) Preparation by the study team of a first-cut "strawman" plan as the basis for starting the integrated plan development process.

(4) Conduct of a planning conference composed of approximately 50 Coast Guard program officers who participated in a series of structured workshops to develop the plan's framework and the content of its main subdivisions.

(5) Refinement of the conference results into final form after several further plan development iterations between the study team and the Coast Guard planning group.

The interaction provided by this procedure ensured that the plan, as it evolved, represented the thinking and expertise of the many Coast Guardsmen involved distilled into a single approach through the dynamics of group interplay.

The plan was developed around a central structural framework of plan design logic in which a set of initial premises about purpose and constraints was established and a specific strategy for generating the plan was subsequently selected and carried out.

Planning Premises

The initial premise was that the RDT&E plan must be integrated in support of the multiple missions described above. The second was that the plan would be oriented to support primarily the Coast Guard's goals for marine safety. (Marine safety was defined to include protection of the marine environment, as well as freedom from accidents causing injuries/fatalities and/or property damage.) The research activities called forth in behalf of this goal included virtually all of those needed to support other Coast Guard goals such as facilitation of maritime commerce and industry. The third premise, adopted for strong analytical reasons, was that the plan would be developed on a problem-solving, as opposed to a programmatic or an opportunistic, basis. From these premises flowed the purposes, constraints, and strategy governing the plan design job.

Planning Strategy

The general description of the planning strategy developed in response to the above constraints was:

> Generate a program of RDT&E projects/tasks whose results would solve the "RDT&E susceptible" problems hampering the Coast Guard's ability to prevent, nullify, or mitigate the consequences of marine casualties in an effective, efficient manner.

The theoretical method for executing this strategy was to carry out successively more detailed dissections of the above-stated general problem. This created a hierarchy of subproblems each of which could be examined to define RDT&E actions that would assist in their solution. As they were identified, these items of work were developed in the format of projects by defining the goals and tasks of each. This theoretical problem-dissection process was complemented by the review of pertinent documents and much intensive, unstructured consultation with Coast Guard experts. Subsequently, estimates of schedule and cost for each work item were made. The resulting array of work items, funding, and time schedules became the substance of the RDT&E plan. Finally, the problem-dissection procedure was used as the basis for a method to evaluate work items as to relative importance so as to facilitate adjusting the plan in response to budget and program schedule constraints.

The most important design technique used in carrying out the problem-dissection methodology was drafting and analysis logic diagrams similar to the "fault trees" used in safety and reliability engineering analysis. A description of the technique is presented in the full report on this research.

First-Level Problem Breakdown. Figure i shows the portion of the logic diagram that represents the first-level breakdown of the general safety problem confronting the Coast Guard. The top box symbolizes the total combined activity of the Coast Guard elements involved placed in a problem-oriented context. This is partitioned at the next level into two subordinate events--the occurrence of the general safety problem and the occurrence of other problems not related to safety concerns. The safety-oriented plan is then developed by further partitioning of Event A into six subevents each denoting a hazard category pertaining to a particular element of the marine domain. These elements comprise a complete listing of the "parties-at-risk" in the event of a marine-domain casualty.

Identification of Primary Problem Areas. The next step was to develop the problem-dissection process to the point where primary problem areas could be identified. This term designates a unique, generic type of system failure equivalent to a marine casualty and involving a single sector of technology within which a coherent set of hazard control actions can be organized, i.e., "occurrence of fires or explosions", "vessel collisions", or "inability to make timely identification of polluting spills". In most cases, primary problem areas act as first causes of the party-at-risk events. Fourteen primary problem areas were identified.

01 Inadequate Problem Analysis, Definition, and Management
02 Harmful Effects of Materials
03 Cargo Degradation
04 Hazardous Material Containment System Primary Failure
05 Collisions, Rammings, Groundings
06 Structural Failures
07 Flooding, Capsizing, Foundering

08 Fires, Explosions
09 Crew/Passenger Hazards
10 Normal Marine Operations-Induced Environmental Degradation
11 Discharge Detection/Identification Failures
12 Discharge Response Failures
13 Transfer Operations Failures
14 Non-Marine-Casualty-Related Failures.

Subproblem Analysis. Primary problem area definitions required further partitioning to reach levels of detail at which RDT&E work items could be uniquely defined. Figure ii illustrates the use of the logic-diagram technique in doing this further partitioning. The example used is primary problem area 07, Flooding, Capsizing, Foundering. Although this problem area is concerned mainly with vessels, the logic diagram is designed to include coverage of the stability problems that may occur with floating work platforms, as well as the more conventional forms of vessels. The main hazard revealed in this diagram is the possible lack of understanding of the stability and seakeeping characteristics of vessels currently under development. This could conceivably lead to the situation of vessels being at sea with unknown hazards relative to their ability to respond adequately to all of the types of sea conditions to which they might be subjected. These problems are developed in the left branch of the diagram. The right branch deals with casualty-related stability problems including that of defining adequate damage stability in vessels. The event shown at the far right, "intentional foundering", was included in the diagram for completeness; no RDT&E-susceptible problems were identified in connection with it. Each primary problem area was dissected in this manner.

Structure of the RDT&E Plan

The plan's structure was derived directly from the framework of the problem-dissection process. The basic structural element is the Project Area. Each Project Area in the plan was defined to be the counterpart of a primary problem area--an individually organized, coherent set of activities aimed at solving the RDT&E-susceptible part of a primary problem area.

The three-level structure was chosen for the plan: (1) "Project Areas" as defined immediately above; (2) "Projects" which address individual subproblems revealed in the dissection process and which are the first-level subdivisions of project areas; and (3) "Tasks" which are the work items comprising projects. Tasks are considered integral parts of projects; they cannot, therefore, be evaluated independently and do not necessarily address a specific subproblem. Projects, however, are defined as addressing specific, unique subproblems and can be manipulated separately as independent elements of the plan.

A six-digit, coded numbering system was chosen as the accountability base for the plan. The first two digits indicate the primary project area; the second two designate the project within that area; and the last two indicate the task. The plan was developed for the five-year period starting in fiscal year 1979. The content of the plan, therefore, is work to be accomplished in that period assuming that work now planned for the interim period is completed.

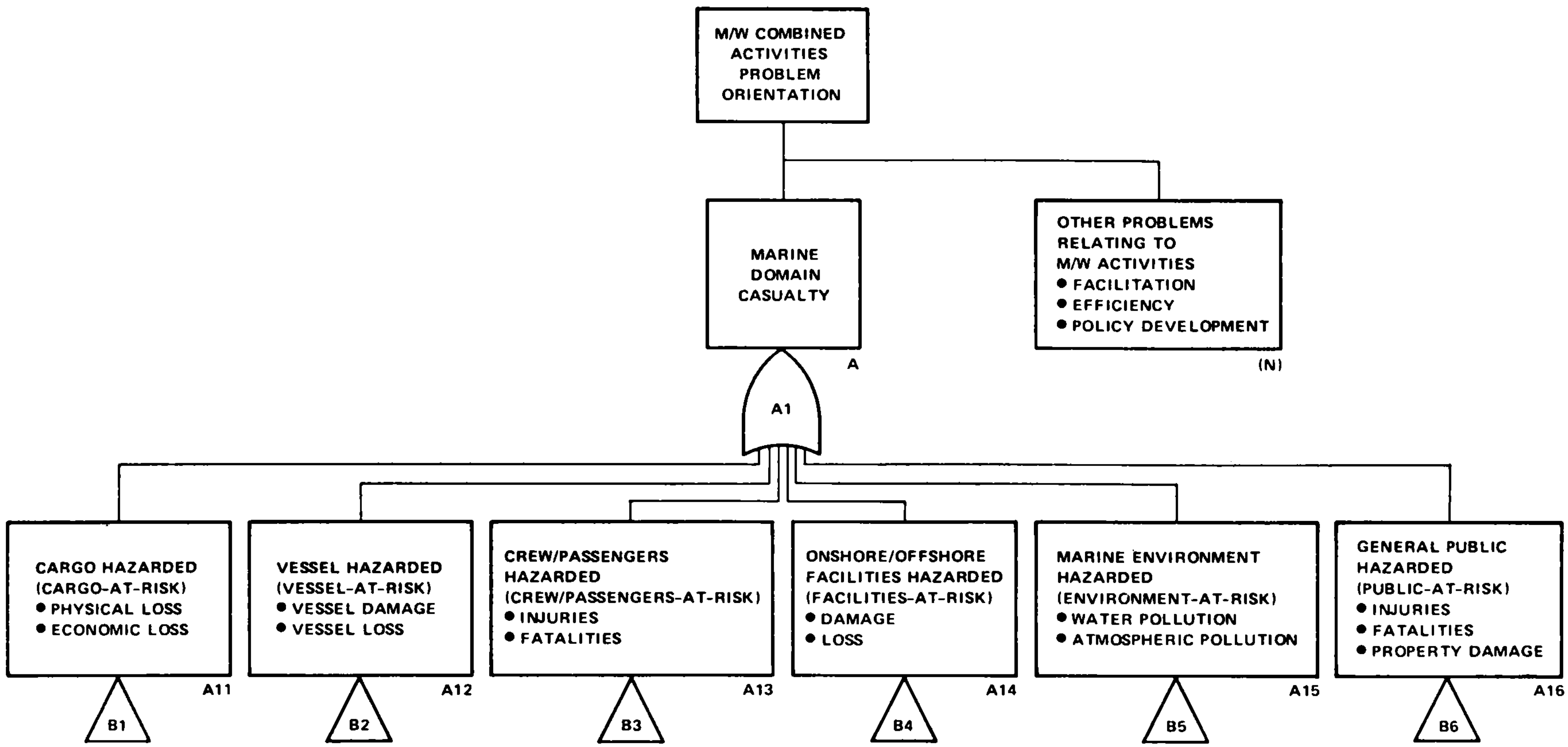

FIGURE i. TOP LEVEL DISSECTION OF A MARINE DOMAIN CASUALTY - PARTIES-AT-RISK

Figure ii

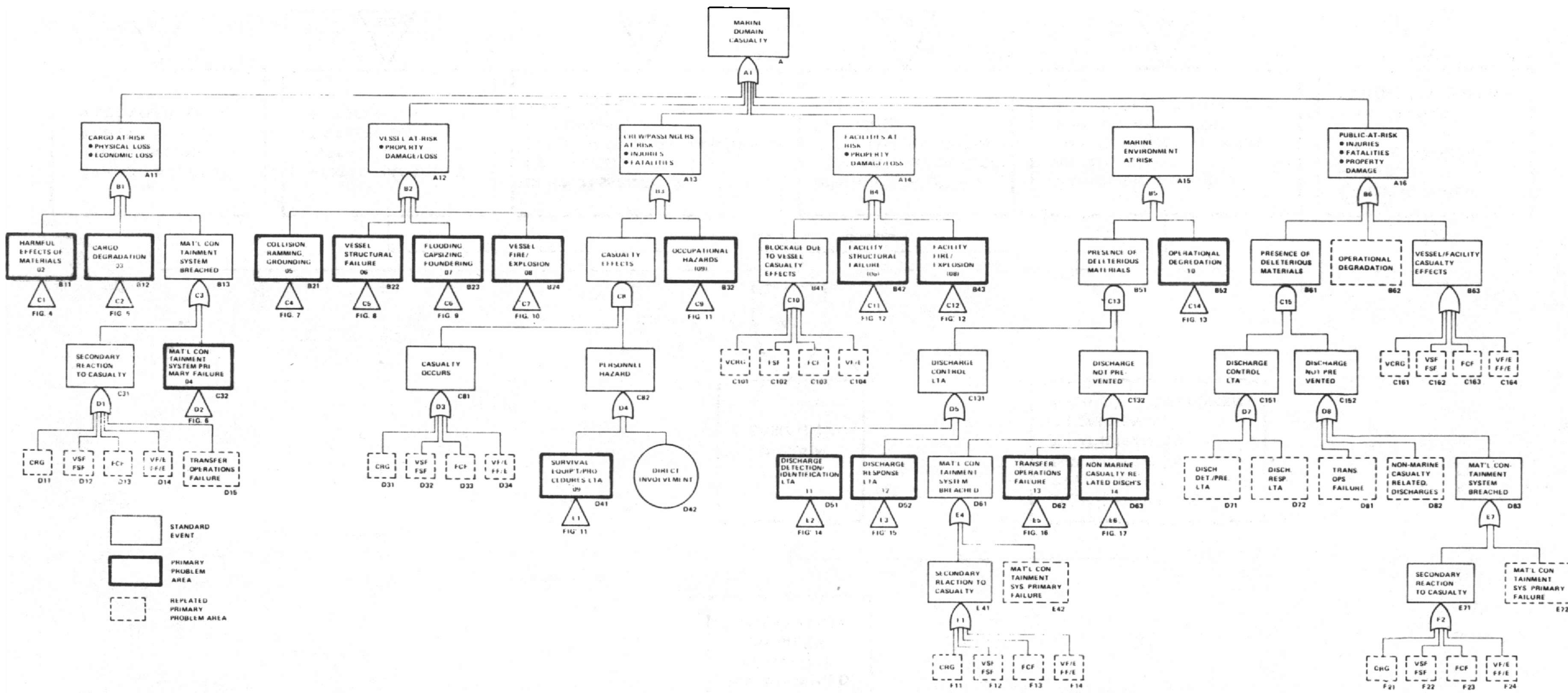

Figure ii Primary Problem Area Logic Diagram

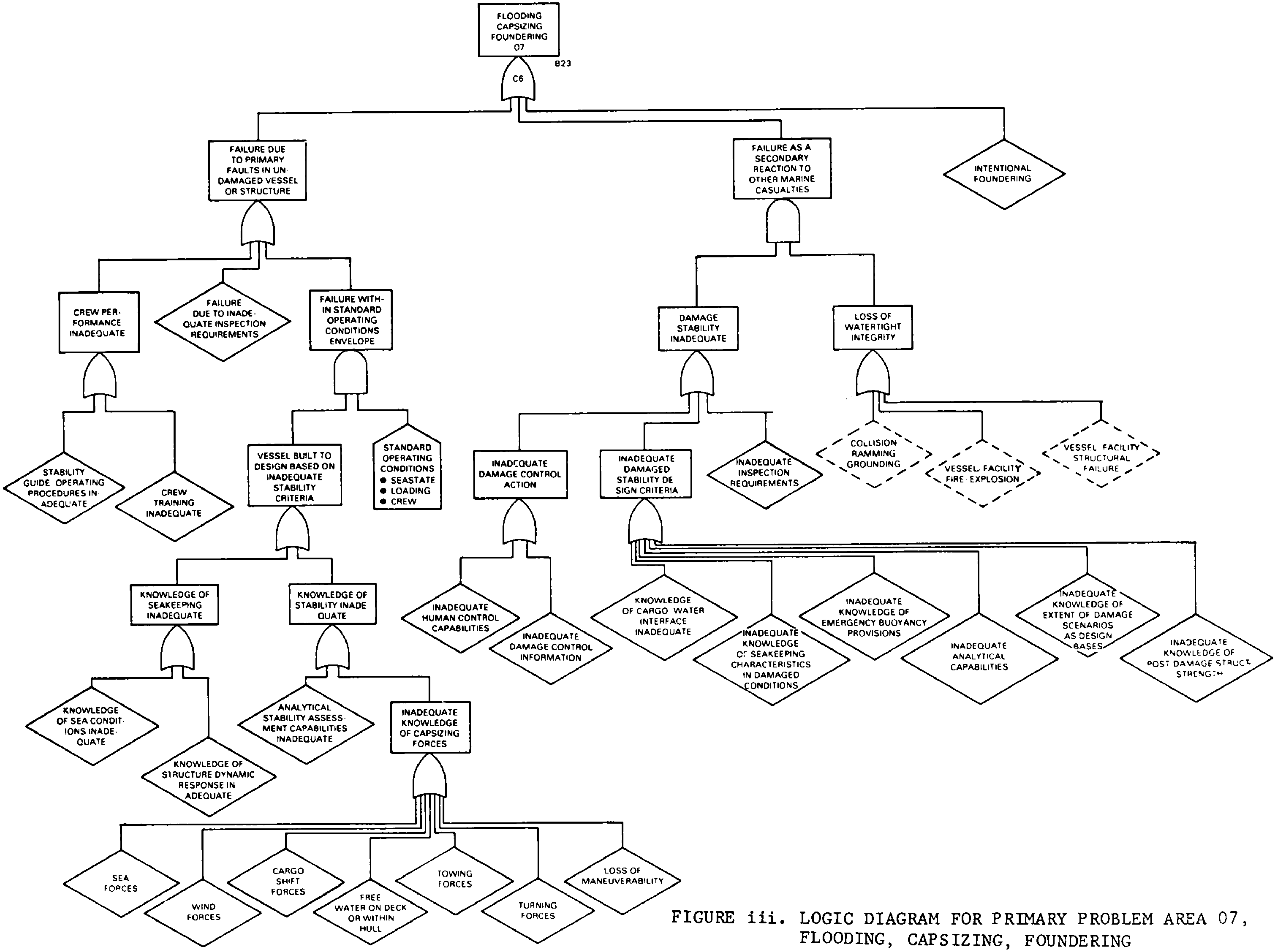

FIGURE iii. LOGIC DIAGRAM FOR PRIMARY PROBLEM AREA 07, FLOODING, CAPSIZING, FOUNDERING

The full plan is presented in tabular form showing two levels of detail and the five-year funding recommendations in Table i. The report of the final program plan contains a discussion of each level of detail along with funding at the task level. The plan as represented in Table i is not budget constrained and includes all of the work items believed appropriate to meet the RDT&E-susceptible parts of the subproblems identified in the analysis.

Modification of the Plan

To be of permanent use, the plan must be dynamic--able to respond to limited budgets and changing conditions. To provide this dynamism in the use of the plan, a methodology was developed to facilitate the process of modifying it by removing, adding, or altering projects. The methodology took the form of a judgmental procedure whereby individual projects could be rated with respect to their relative contribution to solving the RDT&E-susceptible part of the Coast Guard's overall safety problem. Ratings were based on benefit or benefit-cost. The ranking methodology also involved consideration of interdependencies among projects.

Benefit Measures

Benefits are expressed as scalar values representative of the relative seriousness of any problem or subproblem that a work item being evaluated is designed to solve. The seriousness of a safety problem is the risk of both tangible and intangible losses involved in allowing the problem to remain unsolved. The problem-dissection process provides a means of establishing these measures. The process involves first assigning some arbitrary value--say 100--to the "total" marine safety problem. This value is then subdivided in accordance with the logic of the problem-dissection diagrams to arrive at values for the primary problem areas and the subproblems within them. Two judgmental factors are then applied to these values. The factors measure (1) the "access" to the subproblem implied by the scope and depth of the work item's objective and (2) the probability that the work item will be successful in reaching its objective as defined and funded. Projects can be ranked by the resulting benefit numbers.

Benefit-Cost Measures

Another way of ranking projects is by benefit-cost where the benefit numbers are divided by the cost of a project to arrive at the ranking parameter. This ranking implies an ordering of projects by effectiveness with which they utilize budget in addressing safety problems.

TABLE i. SUMMARY OF PROGRAM PLAN

Program Item Number	Project Areas and Projects	Annual Costs - $1000's 1	2	3	4	5	Program Costs, $1000's
010000	PROBLEM DEFINITION	1275	2000	1950	1750	1650	8625
010100	Trend Forecast and Analysis	75	100	100	100	100	475
010200	Marine Safety History Analysis/Eval.	500	400	400	400	300	2000
010300	Risk Management--High Resolution	550	1250	1250	1250	1250	5550
010400	Risk Management--Low Resolution	150	250	200	--	--	600
020000	HAZARDOUS MATERIALS CHARACTERISTICS	1000	1100	1200	1200	1200	5700
020100	Hazard Analysis	300	300	250	300	200	1350
020200	Hazardous Material Containment Req's.	200	200	350	400	500	1650
020300	Hazardous Material Release Behavior	500	600	600	500	500	2700
030000	CARGO LOSS PREVENTION	--	--	--	--	--	--
040000	HAZARDOUS MATERIAL CONTAINMENT SYSTEM SAFETY	650	600	750	775	675	3450
040100	Hazardous Cargo Containment Management System Analysis	400	300	300	300	300	1600
040200	Containment System Loading Induced Structural Design Criteria	200	200	200	100	--	700
040300	Cargo System Inspection Requirements	50	100	100	200	50	500
040400	Cargo System Maintenance Analysis	--	--	100	100	200	400
040500	Crew/Cargo Interface Analysis	--	--	50	75	125	250
050000	COLLISION/RAMMING/GROUND PREVENTION	6905	6810	6820	5930	5305	31770
050100	Preliminary Analysis & Sys. Overview	125	125	125	125	125	625
050200	Analytic Study of Controllability	--	250	250	250	300	1050
050300	Human Factors in Navigation	900	1150	900	700	600	4250
050400	Vessel Maneuvering Characteristics	820	660	400	--	--	1880
050500	Navigation Gear Failure Prevention	200	250	300	100	--	850
050600	Vessel Damage Resistance Analysis	--	--	200	200	300	700
050700	Vessel Traffic Management Technology	1700	1200	1200	1000	750	5850
050800	Bridge Protective System Guidelines	100	150	50	100	100	500
050900	Short-Range Aids to Navigation	1140	965	1285	1125	1210	5725
051000	Radio Aids to Navigation	1920	2060	2110	2330	1920	10340
060000	STRUCTURAL FAILURE	1280	2030	1485	2365	1560	8720
060100	Interagency Cooperative Res. Proj.--SSC	200	205	210	215	210	1040
060200	Structural Loading Design Criteria	450	750	600	1150	600	3550
060300	Structural Material Design Criteria	150	250	50	150	200	800
060400	Structural Response Criteria	130	200	150	200	150	830
060500	Vessel Inspection Requirements	150	275	225	300	180	1100
060600	Vessel Maintenance Analysis	100	100	100	150	100	550
060700	Structural Stress Management Feasibility Analysis	100	250	150	200	150	850
070000	FLOODING, CAPSIZING, FOUNDERING HAZARD CONTAINMENT	1210	1625	1575	1025	550	5985
070100	Intact Vessel Stability Criteria	350	525	550	225	100	1750
070200	Damaged Structure Stability Criteria	330	450	275	200	100	1355
070300	Seakeeping Criteria	405	450	425	350	200	1830
070400	Crew Performance Requirements	50	100	225	225	150	750
070500	Inspection Requirements	75	100	100	25	--	300
080000	FIRE/EXPLOSION HAZARD CONTROL	525	905	1350	1115	700	4745
080100	Vessel Fire Fighting Technology/ Procedures	150	250	375	300	200	1275
080200	Vessel Fire Resistance & Cargo Insulation	100	200	250	100	100	750
080300	Vapor & Fire Detection Equipment	100	175	150	250	75	750
080400	Vapor Ignition	75	180	200	250	175	880
080500	Purging Methods	--	--	125	100	50	275
080600	Fire Prevention/Fighting Offshore	100	100	50	100	100	450
080700	Fire Prevention/Fighting at Conv. Ports	--	--	200	15	50	365

TABLE i. (Continued)

Program Item Number	Project Areas and Projects	Annual Costs - $1000's 1	2	3	4	5	Program Costs, $1000's
090000	PERSONNEL SAFETY AND SURVIVABILITY	945	1885	2235	1875	790	7730
090100	Crew/Passenger Survival Systems	175	325	250	250	75	1075
090200	Preabandonment/Casualty Response	80	100	120	100	40	440
090300	Group Survival Systems	200	270	300	300	150	1220
090400	Individual Survival Equipment	50	150	300	200	100	800
090500	Retrieval Equipment	125	300	275	75	25	800
090600	Underwater Rescue Vehicle	50	110	200	250	--	610
090700	Submersible Survivability Standards	40	80	140	100	100	460
090800	Cargo Vapor Monitoring Survival Equip.	75	225	350	300	200	1150
090900	Industrial Diving Standards	150	325	300	300	100	1175
100000	NORMAL MARINE OPERATION - INDUCE ENVIRONMENTAL DEGRADATION MINIMIZATION	--	--	--	--	--	--
110000	DISCHARGE DETECTION AND IDENTIFICATION	3140	1600	1860	2150	950	9700
110100	Oil Discharge Surveillance Systems Development	1850	250	100	--	--	2200
110200	Nonoil Discharge Surveillance Systems Development	--	300	700	1300	750	3050
110300	Dev. 2nd Generation Oil Identification Systems	590	405	500	500	100	2095
110400	Dev. Nonoil Identification Systems	650	595	560	350	100	2255
110500	Ocean Dumping Surveillance	50	50	--	--	--	100
120000	DISCHARGE RESPONSE	6825	6900	5500	3575	1325	24125
120100	Dev. of Techniques for Oil Discharge Response	4675	4175	2850	2025	625	14350
120200	Dev. Nonoil Discharge Response Tech.	1600	2100	2000	1000	500	7200
120300	Spill Response Logistic Requirements	100	300	450	350	100	1300
120400	Personnel Training & Protection	450	325	200	200	100	1275
130000	HAZARDOUS MATERIAL TRANSFER SYSTEM FAILURE PREVENTION	190	415.	370	210	125	1320
130100	Liquid Bulk Conventional Terminal Analysis	75	150	75	50	50	400
130200	Hazard Assessment Dry Bulk Facilities	25	50	65	110	25	285
130300	Hazard Assessment Break Bulk Facilities	40	75	75	--	--	190
130400	Hazard Assessment Offshore Oil and Gas	--	40	80	50	50	220
140000	NONMARINE CASUALTY-RELATED DISCHARGE PREVENTION	500	1150	1150	900	550	4250
140100	Waste-Water Pollution Abatement	500	1000	1000	700	500	3700
140200	Vapor Recovery Systems	--	150	150	150	--	450
140300	Discharge Problem Analysis	--	--	--	50	50	100
	Program Totals	24,445	27,020	26,245	22,870	15,380	115,960

Project Interdependency

The projects in the plan have supporter-supported interrelationships where one project provides another with data, knowledge, procedures, or experimental equipment needed in pursuing the latter's objective. Such interdependencies must be considered when the plan is being modified; if modification involves removing or changing a supporter project, the impact on the supported project must be recognized and dealt with as a part of the modification. In forming the plan therefore, such interrelationships were flagged in the project descriptions and an overall display of these interrelationships were included as a graphic illustration. The direct means of accounting for interdependency effects is to represent the impact of removing or altering supporter projects as changes in the supported project's benefit and cost values.

FOREWORD

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DISCLAIMER

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LIST OF ACRONYMS AND SPECIAL TERMS

A/N - Aids to navigation

API - American Petroleum Institute

CEQ - Council on Environmental Quality

CHRIS - Chemical Hazard Response Information System

CRG - Collision, ramming, grounding

CVS - Commercial vessel safety

DOD - Department of Defense

DTNSRDC - David Taylor Naval Ship Research and Development Center

DWT - Dead-weight tonnage

ERDA - Energy Research and Development Administration

FCF - Flooding, capsizing, foundering

F/E - Fire/explosion

FMECA - Failure mode and effects criticality analysis

GIFTS - Graphical interaction of finite element time sharing system

HHE - Harbor and harbor entrance

IMCO - Inter-Governmental Maritime Consultive Organization

LNG - Liquified natural gas

LORAN-C - Precision radio aid to navigation

LTA - Less than adequate

M (or Office of M) - Office of Merchant Marine Safety, a first-tier subdivision of the Coast Guard organization

Marine Casualty - An occurrence involving the marine domain resulting in any of the following: injuries/fatalities, significant property damage, damage to the marine environment

Marine Domain - A universe defined for analytical purposes as consisting of vessels, personnel, facilities and other property both off- and onshore, cargo, passengers, waterways, and all commercial and recreational activities carried out in the oceans and inland waterways of concern to the Coast Guard

Marine Safety - Freedom from marine domain occurrences hazardous to (1) life and well being of people, (2) property, and (3) the marine environment

MSIS - Marine Safety Information System

MSD - Marine sanitation device

NAE - National Academy of Engineering

NAS - National Academy of Science

NASA - National Air and Space Administration

NOAA - National Oceanographic and Atmospheric Administration

OCS - Outer continental shelf

OTEC - Ocean thermal energy conversion

PIRS - Pollution incident reporting system

Primary Problem - A unique, generic type of systemic failure or accident that is equivalent to a marine casualty and involves a single sector of technology

Project - Second subdivision of the RDT&E plan; a main activity element aligned with a specific subproblem

Project Area - Top subdivision of the RDT&E plan designating a program-type set of activities aligned with Primary Problems

PSRS - Port safety reporting system

RA - Radio aids

RDT&E - Research, Development, Testing, and Evaluation

RO-RO - Roll-on - roll-off cargo vessel

SF - Structural failure

SSC - Ship Structures Committee

Task - Third subdivision of the RDT&E plan; an integral step or part of a project

ULCC - Ultra-large crude carrier

VIIS - Vessel Inspection Information System

VLCC - Very large crude carrier

VTS - Vessel Traffic Services

W (or Office of W) - Office of Marine Environment and Systems, a first-tier subdivision of the Coast Guard organization

1.0 INTRODUCTION

FINAL REPORT

on

RDT&E PLAN FOR MARINE SAFETY

by

E. S. Cheaney, R. D. Leis, and A. J. Coyle

1.0 INTRODUCTION

This report presents the results of a study of future research needs in marine safety and environmental protection carried out by Battelle's Columbus Laboratories under the auspices of, and with the participation of, the U. S. Coast Guard. The study has, as its principal output, an RDT&E plan describing work that would provide effective research support to the Coast Guard. The most significant feature of this plan is that it combines the research needs of all of the Coast Guard's programs relating to marine safety and environmental protection into a single, integrated plan of action.

1.1 BACKGROUND

The U. S. Congress has passed several laws that, as a composite, charge the U. S. Coast Guard with broad responsibilities and authority to enhance safety in the marine domain. Some of these laws:

(1) PL 92-340, Ports and Waterways Safety Act of 1972

(2) PL 92-500, Federal Water Pollution Control Act Amendments of 1972

(3) PL 93-119, Oil Pollution Act Amendments of 1973

(4) 46 USC 391, Steamship Act (RS4417)

(5) 46 USC 391a, Tanker Act of 1936 (RS4417)

(6) 46 USC 170, Explosive and Dangerous Cargo Act

(7) 46 USC 222, Vessel Manning Requirements (RS4463)

(8) PL 93-627, Deepwater Port Act of 1974

(9) 33 USC 1331, Outer Continental Shelf Lands Act of 1953.

The general effect of the older of these laws has been to charge the Coast Guard with its traditional responsibility for protecting passengers, crews, and vessels from injury and damage through the exercise of its various regulatory powers and the provision of services such as Aids to Navigation. The more recent of these laws, particularly the first on the preceding page, extend the scope of the Coast Guard's safety responsibility to make protection of the marine environment an explicit objective and to expand the Coast Guard's powers accordingly. This was a drastic extension of the Coast Guard's responsibilities and, because of the concomitant involvement in new technological issues, posed the need for the Coast Guard to sharply increase its RDT&E activity. A large amount of new information, data, and prototype equipment had to be generated. To support budgetary and other kinds of planning, a systematic RDT&E programming effort was launched.

In 1973, a Coast Guard document, "Development of an RDT&E Program Plan Related to Marine Safety and Environmental Protection", was published. It was prepared by Battelle-Columbus with the close collaboration of Coast Guard officials. The plan was designed to support the Coast Guard's activities with respect to Title II of PL 92-340, the Ports and Waterways Safety Act. It prescribed research efforts and costs needed to produce new knowledge and information useful in identifying risks, investigating stringency levels of regulatory actions, and establishing the feasibility of regulatory actions or services. Although designed to respond to Title II, hence limited in scope to liquid bulk cargo vessels, the resulting plan closely approached full support of the Commercial Vessel Safety (CVS) program.

In 1974, this RDT&E plan was updated and expanded to encompass the full CVS program. The updating was issued as an addendum to the 1973 plan. The plan, in this form, was utilized by those components of the Coast Guard involved in the CVS program--mainly the various Divisions in the Office of "M". They used the content of the plan as an input for programming of specific projects. The structure of the plan was utilized as the basis for setting up a management and review organization known as the "M Research Council" which plans and coordinates the RDT&E effort of that Office. This successful use of the plan for the CVS program led to the Coast Guard's decision to undertake the project reported on herein.

1.2 PURPOSE

Two interrelated purposes were served in the development of tnis plan. First, conditions have changed sufficiently since the last update of the CVS RDT&E Plan to justify a thorough reexamination and, possibly, a revision of the plan. Even though a substantial number of the research objectives in that plan have been achieved, new problems requiring research support have arisen and the form of others has changed in a variety of ways. The technological environment in which the marine industry functions continued to be altered by the introduction of advanced technology, such as Boeing's advanced hydrofoil vessels and new commercial requirements such as those for moving radioactive materials by water in connection with the growth of the nuclear power industry. The emphasis on various aspects of the Coast Guard's responsibilities for CVS has shifted with these changes. For example, new responsibilities devolving in part on the CVS program have arisen as a consequence of the passage of the Deepwater Port Act. Thus, a full review and revision of the CVS plan was in order.

Second, a basic decision was made at Coast Guard Headquarters to explore the feasibility and utility of expanding the scope of the plan to include RDT&E support for the programs being carried out in the Office of "W", as well as the CVS program carried out in the Office of M. These programs are:

- Aids to Navigation
- Bridge Administration
- Marine Environmental Protection
- Port Safety and Security
- Deepwater Ports Project
- Ports and Waterways Planning.

Each of these program requires RDT&E support. In many cases, the topics to be studied overlap among these programs and the CVS program so that work is unnecessarily duplicated. It was suspected that a substantial improvement in the efficiency with which the Coast Guard utilizes its RDT&E resources would result from the establishment of a fully integrated plan covering the needs of all the above programs together. Furthermore, such integration would provide a more effective instrument for establishing needed budget levels and exercising budgetary control of the overall RDT&E effort.

Thus, the purpose of this study was to develop an RDT&E plan that reflects a thorough updating and modernization of the CVS plan and integrates with it the RDT&E support requirements of the other six programs listed on the preceding page. The plan was to be developed so as to respond only to the integrated support needs of these programs. It was not intended to recognize in any way which organizational element of the Coast Guard might eventually be selected to be responsible for executing any part of the plan. Nor was the probable categorization of elements of the plan for appropriate funding to be considered. Any identified item of needed work that required an investigatory approach to solve some defined problem and produced an output definable as the product of a research effort was to be included regardless of whether it would be funded from research or operating budgets. Specifically, the program is <u>not</u> to be confined to work done only by the Coast Guard's Office of Research and Development.

1.3 ORGANIZATION OF THIS DOCUMENT

Following this Introduction, Section 2.0 describes in detail how this plan was developed. This includes the procedures carried out, the development of the structure of logic on which the plan is based, and the identification of the projects and tasks of which the plan is composed. Section 3.0 presents the plan itself in a standardized descriptive format. Section 4.0 covers the subject of techniques and approach to modifying the plan in the future.

2.0 DEVELOPMENT OF THE RDT&E PLAN

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The plan was developed by carrying out a procedure aimed at promoting close collaboration between the Battelle study team and the officers and civilian specialists at Headquarters playing key roles in the different programs involved. Specifically, the following steps were carried out:

(1) The study team obtained and studied internal Coast Guard documentation and records concerning the recent history and present commitments and plans for the research effort supporting each of the programs.

(2) A series of seminars was held during which the study team discussed missions, mission problems, and RDT&E needs with representatives of each of the Office of W's Programs and each of the Office of M's Divisions.

(3) Based on the results of (1) and (2), an initial, integrated plan was prepared. This plan was termed the "strawman" plan since it was intended solely to elicit feedback from the Coast Guard participants and to serve as a point of departure for a planning conference.

(4) A Planning Conference was then held at the Coast Guard's Yorktown training center to analyze, discuss, and revise the strawman plan. Approximately 50 Coast Guard officers and civilian specialists attended, most of these being participants in the seminars [Item (2) above]. The conference's basic activity was a series of workshops, devoted to consideration of the logical structure and project content of the plan.

(5) Following the Planning Conference the results were restructured into an integrated plan and this report was prepared and submitted.

The interraction provided by this procedure was utilized by the Battelle study team to ensure that the plan, as it evolved, represented the thinking and intentions of the Coast Guard staff. Although the study team structured the plan and acted as a sounding board during its development, the basic content of the plan--the projects identified as being needed and the goals toward which they were to be directed--came mainly from the Coast Guard participants.

The process by which the plan was developed involved a sequence of steps which were followed in an iterative manner with a considerable amount of recycling and feedback. First, a set of premises about the planning problem were defined. Then a strategy for developing the plan was determined and a structure evolved. Finally, the content of the plan was identified and budgeted. These steps were followed by the study team in developing the strawman. They were essentially repeated by the attendees at the planning conference in reacting to the strawman.

2.1 PLANNING PREMISES

The basis of developing any plan is a set of premises which define what the plan is about, what its underlying purpose is, and the restrictions, if any, that must be observed in working it out.

In this case, the first and most important planning premise was that the RDT&E plan must present the research support needed for the combined M and W missions and this presentation must be in a unified, internally consistent format purged of redundancy. This premise led to the definition of two others. The first was concerned with the goal orientation reflected by the combined missions; this, for obvious reasons, was crucial to the development of the plan. The second had to do with whether the plan's basic mode should be that of executing defined programs, capitalizing on a variety of opportunities, or seeking solutions to a set of perceived problems.

2.1.1 Goal Orientation Premise

The goal of the RDT&E plan, expressed in the most general terms, is to support the Coast Guard's execution of its missions. Such support consists of providing new knowledge, information, procedures, or equipment prototypes which make it possible to carry out the missions or which make their execution more effective. For example, to carry out the mission of enforcing Federal laws concerning polluting spills, it is essential that the Coast Guard have the technological capability to detect them in a reliable and timely manner. R&D activity supports that mission by developing and qualifying the necessary detection devices. This has the effect of filling a gap in a capability. Similarly, a mission may be hampered by a lack of readily retrievable information pertinent to the execution of the mission. R&D can fill such an "information gap" by conducting suitable information-gathering investigations and, possibly, developing a computerized storage and retrieval system for manipulating it in the manner that is most effective for efficient discharge of the mission responsibilities. These examples indicate how closely related are the details of a mission activity and the kinds of RDT&E actions that can give it valid and useful support. It follows that the specific direction to be taken by the RDT&E program could only be determined from analysis of the nature and purposes of the activities it was intended to support.

The study team formed the conclusion, based on program documentation and interviews with key program personnel, that the activities of the two Offices fell mainly into four categories: (1) those devoted to enhancing/maintaining safety in the marine domain, (2) those concerned with protection of the marine environment, (3) those aimed at facilitation of marine industry, and (4) those intended to improve the efficiency with which the Coast Guard performs all its jobs. Other kinds of activities were also in evidence; for example, work supporting the development of policy concerning the utilization of national water resources. However, the four categories enumerated above seemed to be the main ones to consider in developing the RDT&E plan.

Note that, in most cases, program activities fell into two or more of these categories. The Aids to Navigation program, by creating navigable waterway paths, is obviously filling a facilitation role. However, the basic purpose of the Aids program is to create pathways that are <u>safe</u> to use. Facilitation results only to the extent that safe pathways can be devised. Furthermore, an important and new consideration in the Aids program is the creation of navigational facilities and standards that will minimize the occurrence of ramming and grounding and the consequent spills that create a hazard to the marine environment. Avoiding rammings and groundings has always been a motivating factor for the Aids program, but the emphasis on protection of the marine environment has greatly intensified efforts across the board to reduce the potential for the occurrence of these types of accidents. But safety cannot be the only recognized goal. Imposition of extreme measures to assure the maximum safety in marine transportation would be incompatible with an effective, economic transportation system. In fact, the ultimate step - abolishing marine transportation - would eliminate all accidents attributable to its existence. On the other hand, an extreme disregard for safety also would be counterproductive to expeditious, economic movement of marine traffic. An appropriate balance must be struck between safety and free, rapid movement. Specific Coast Guard program activities may be viewed as providing services which facilitate marine transportation by allowing it to move as freely and expeditiously as possible without an unacceptable degradation of safety, or as regulating transportation to assure an acceptable level of safety without unnecessary or unreasonable interference to economic, expeditious flow of traffic. A safety-oriented R&D plan might be conceived as serving both the safety and facilitation of marine transportation by providing the knowledge necessary to strike an optimum balance between the two.

In view of this, a basic decision was needed as to whether the RDT&E plan should be oriented to support explicitly all four of the activity categories listed on the preceding page or should be concentrated on a subset. The decision was important to the plan's design and completeness; if the former option were chosen, the plan would be more likely to include all the items belonging in it but the planning approach would have to be based, possibly unnecessarily, on a multiple-goal requirement--a much more complex and difficult process from the standpoints of the design techniques that would have to be employed and the need to develop a method for establishing priorities among projects. If the latter option were chosen, the tasks of design and priority determination would be more straightforward and adaptable (though still formidable) but an increased possibility of overlooking the need for important RDT&E items in the plan would exist.

These issues were first confronted by the study team which developed a preference for the latter option. However, the matter was considered important enough to be brought up as a specific agenda item during the Planning Conference at Yorktown. There it was analyzed and discussed by the full Conference. The result was a decision that succeeded in resolving both issues. It was to orient the RDT&E plan's formal design toward a single goal ". . . to support all activities concerned with marine safety and environmental protection", but to include a companion, "all other" goal category as a means of collecting RDT&E items supporting unrelated activities. The rationale for this decision was based on the conviction of all participants that:

(1) Due to the extensive overlap among the goal categories into which the M/W activities fall, the RDT&E efforts needed to support marine safety and/or environmental protection will include nearly all of the effort needed to support all such activities.

(2) The named goal orientation can be regarded as a singular one (for planning design purposes) by virtue of a convention adopted by the Conference. This convention was that any polluting spill occurring in the marine environment be

defined as a marine casualty, hence, a safety deficiency or violation in the same sense that accidents causing injuries/ fatalities and/or property damage are so regarded. Based on this convention, the term "marine safety" includes implicitly "marine environment protection". The briefer term will be used from this point in this report.

(3) The "all other" category would suffice to collect whatever program items not related to marine safety are identified as deserving inclusion in the RDT&E plan. Since the number of such items was expected to be small, the problem of establishing their priority on a basis common with the rest of the plan's content could be attacked on an individual case basis.

Thus, the goal orientation premise was that the RDT&E plan was to be designed to support the safety activities of the M and W Offices in the marine domain. As noted above, the term "safety" was broadly defined to include freedom from occurrences hazardous to: (1) life and well-being of people, (2) property, and (3) the marine environment. The scope of the goal orientation is also broadly defined as covering the full "marine domain"--a term arrived at by the Conference. The marine domain includes vessels, personnel, facilities and other property both onshore and offshore, cargo, passengers, the waterways, and all commercial (including offshore oil, gas, and mining) and recreational activities carried out in the oceans and inland waterways of concern to the Coast Guard.

2.1.2 Planning Mode Orientation Premise

By "planning mode" is meant the approach taken as a response to the nature or character of the activities being supported by the RDT&E effort. In this case, the activities of the M/W Offices have the character of a set of <u>programs</u> aimed at achieving objectives defined by legislation or tradition. If this mode were carried into the design methodology, the RDT&E design effort would be thought of and rationalized as providing various types of program support to help meet this nonhomogeneous cluster of goals. Alternatively, however, the Offices' activities have other characteristics which might usefully be invoked for design purposes, for example they might be thought of as a set of <u>ventures</u> seeking to capitalize on opportunities to achieve desired ends, or as a group of directed efforts to solve a hierarchy of <u>problems and subproblems</u>. Thus, one can choose a "programming", "venturing", or "problem solving" mode of planning.

The distinctions among these modes were considered significant to the plan's design approach. In the first instance, the plan would be based on a nonhomogeneously determined set of goals and would be developed through successive breakdowns of these goal statements. In the second case, the plan's design would have to remain adaptible and open-ended so as to be responsive to both short- and long-term opportunities. In the third, the design process would take the form of developing directed, alternative solutions to problems/subproblems defined in a hierarchical form from a single, all-embracing problem definition.

The problem-solving mode was adopted in the case of the predecessor RDT&E plans developed for the CVS program. In the current project, the decision to utilize the problem-solving mode was reiterated; this decision was ratified at the Planning Conference. In comparison to the other planning modes, problem solving appeared to provide the most direct response to the needs of the M/W activities; it had the tightest logic on which to rationalize the plan, and it seemed most commensurate with Coast Guard management's concepts of the role RDT&E is expected to play in support of mission activities.

In practicing this mode of design, it was recognized that two different but closely interrelated problems had to be dealt with--one external and one internal. The external problem is the potential in the marine domain for the occurrence of accidents. In accordance with the goal orientation premise, the combined M/W mission activities were viewed mainly in their roles of contributing to the solution of that problem, i.e., reducing the potential for accidents and mitigating their consequences when they do occur. The mission subgoals could be systematically defined by breaking down all the causes of marine accidents into subproblems and aligning mission goals to overcome them.

The internal problem is the complex of factors which in any way hamper the Coast Guard's performance of these mission activities. Many such factors exist, as illustrated by these examples: (1) vessel inspection is currently hampered by a shortage of qualified manpower to meet the workload; (2) in some locations there are insufficient patrol craft or crews to carry out the spill surveillance mission adequately; (3) the rate of buoy deterioration in service imposes an economic load--a problem--on the Coast Guard's mission of establishing and maintaining the navigation aids system; (4) the spill detection mission is seriously hampered by the absence of a practical, sufficiently accurate detection device; (5) the basic mission to generate regulation packages governing the movement of hazardous materials by water does not have sufficiently timely data and information on the chemical, stowage, and release behavior properties of the materials. Hampering problems like these can be cited for every mission and activity carried out in the M/W domain.

It was evident that only part of these internal problems are solvable through RDT&E efforts. The workload and patrol craft problems cited in the first two examples on the preceding page might be somewhat alleviated by the development of new technologies or procedures to improve the effectiveness of the resources presently in use, but the basic solutions probably entail increasing the resources. On the other hand, development of a new, more effective spill detection device would clearly be an RDT&E job; so also would be creating means such as better coatings to inhibit the deterioration rate of buoys to extend their economic life. Further, the development of data on properties of hazardous materials is an activity falling in the class of technology support for a critically important regulatory activity. Thus, some of the internal problems are susceptible to RDT&E solutions and some are not. It follows that, in developing the RDT&E plan, the basic thesis would be to seek out the "RDT&E-susceptible" subproblems and work out an array of project work designed to solve them.

2.2 PLANNING STRATEGY--PROBLEM DISSECTION

Stipulation of the planning premises on M/W integration, marine safety orientation, and problem-solving mode led directly to postulating the basic strategy for developing the plan. A general statement of the strategy was:

> Generate a program of RDT&E projects/tasks whose results would solve the "RDT&E-susceptible" problems hampering the Coast Guard's ability to prevent, nullify, or mitigate the consequences of marine casualties in an effective, efficient manner.

Note that this statement explicitly defines as a problem the failure to carry out safety activities with efficiency. This by definition, admits to the RDT&E effort projects aimed at improving Coast Guard efficiency and effectiveness. For purposes of executing this strategy, a "marine casualty" was defined as: "An occurrence involving the marine domain resulting in any of the following:

- Injuries/fatalities
- Significant property damage
- Damage to the marine environment.

The theoretical method for executing this strategy was to carry out successively more detailed dissections of the above-stated general problem to create a hierarchy of subproblems. As the subproblems were revealed, each was to be examined in the light of the current and projected array of M/W mission activities to define the internal problems present that might be solved or mitigated through RDT&E action. As they were identified, these items of work were then to be developed in the format of projects by defining the goals and tasks for each. Subsequently, cost estimates for each item were to be made and associated with time schedules for meeting the goals. This array of project/task descriptions, schedules, and funding requirements became the substance of the RDT&E plan.

The above description is an idealized picture of the plan development process. Although this was the underlying pattern of events, the process was actually highly iterative. Though some subproblems were identified as a result of the top-down analysis process described above, more were identified in other ways. The most important of these was the creative effort of the Workshops conducted as a part of the Planning Conference. Another was examining the past history of the RDT&E being conducted in support of both the M and W Offices and the future requirements both had identified and already put on the record. Subproblem identifications arose during casual conversations, as a result of creative suggestions from outsiders, and from a variety of other sources. All of these inputs were useful and were successfully integrated into the plan. This proved to be possible through the rationalizing power of the subproblem dissection process.

As in the development of the prior RDT&E plans supporting the CVS program, it was found useful to use logic diagrams to generate and record the problem/subproblem array. The diagrams are graphical representations of the subdivision process using AND/OR logic to clarify the relationships among subordinate events. A diagram is started at the top by postulating some top level, undesired event such as "occurrence of a marine casualty" or "large-scale spill". This defines the general problem being investigated through the method of the logic diagram. The remainder of the diagram is then formed by representing, at each successive lower level, the identified, possible causes of each of the events at the next level up. If the top-level event is some type of marine accident or casualty, then the lower levels will call out the set of failures or errors which might cause that accident. Of course, at each level the causes thus cited are also events which in turn have their own,

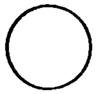
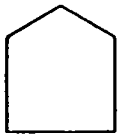
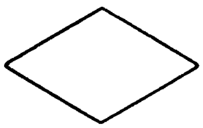
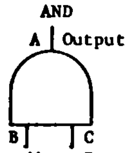
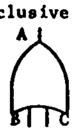
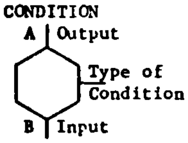
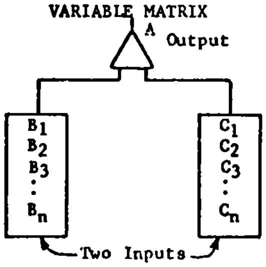
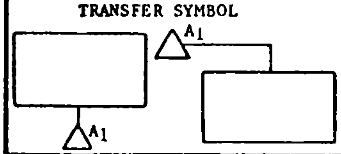
RECTANGLE 	This symbol represents the top undesired event or any intermediate event. Expressed in form of a proposition, statement set, or outcome of an observation.
CIRCLE 	A basic event requiring no further development for the purpose of analyzing the particular logic diagram. Defined as an "independent output" event or as a "primary" event.
HOUSE 	An event that must occur, or is expected to occur, as a normal operating condition of the system. It is not a failure or fault event.
DIAMOND 	An event arbitrarily treated as basic in a logic diagram so that it is not developed further.
OVAL 	An event that is a conditional input to a condition gate (see below). Defines a particular state of the system in which an input event may occur. It may be a normal condition or a failure.
AND  Two or More Inputs	An AND gate describes the logic operation whereby the coexistence of all input events is required to produce the output event.
Inclusive OR  Two or More Inputs	An OR gate describes the logic operation whereby the output event will exist if one and/or more of the input events exists.
CONDITION  	A "general inhibit" gate (or "condition" gate) describes a causal relationship between one event and another. The input event directly produces the output event if the indicated condition is satisfied. May be treated as an AND gate in logical analysis.
VARIABLE MATRIX  	A "matrix" gate describes a situation where an output event is produced for certain combinations of events at the inputs. Input combinations are indicated by a (1) in the diagonal squares of the matrix and (0) for all other squares. Only combinations having the value (1) are considered in the event combinations.
TRANSFER SYMBOL  	A transfer symbol is used to indicate continuity between two parts of a logic diagram. An alphanumeric symbol (A_1) indicates the part of the diagram to which, or from which, the transfer is made.

FIGURE 1. LOGIC DIAGRAM ELEMENTS AND THEIR MEANINGS

more detailed sets of causes. Beneath each event in the diagram is placed either an AND or an OR symbol. These are used to distinguish between causes for an event which must all operate or occur simultaneously for that event to occur (AND events) and alternative causes which could each independently produce the upper level event (OR events). Figure 1 gives illustrations and explanations of these and other symbols used in the logic diagrams. The use of these diagrams will be exemplified in the following discussion of the steps in the problem dissection process.

2.2.1 First Level Problem Breakdown

Figure 2 shows how the logic diagram illustrating the upper level breakdown for this planning design program was begun. For convenience in making reference to various parts of this diagram and those developed from it later, an alpha numeric code was used to designate each event and logic symbol. A letter indicates the level of a set of events and the logic symbol indicating their relationship to the upper event. A single digit number indicates the location of a logic symbol horizontally on the diagram. A two digit number does the same for the events located under each logic symbol.

The top box in Figure 2 symbolized the total combined activity of the Offices of W and M put in a problem oriented context, i.e., all the activities of the two Offices thought of as being directed to overcoming external or internal problems. Thus, expressed as an event, the box states the occurrence of all the conditions which motivate M and W Office activity.

This "event" was partitioned at the next level into two subordinate events: the occurrence of casualties in the marine domain--the general safety problem--and the occurrence of other problems not related to safety concerns. This partitioning is a graphic portrayal of the decision made during the Planning Conference to handle the major part of the plan development job as being safety related incorporating the remainder in an "all other" goal category. The general casualty event was designated as event A; the formally designed plan was developed from the subproblems generated out of that event. The "all other" category, event N, was not formally developed further since it was used only as a collection point.

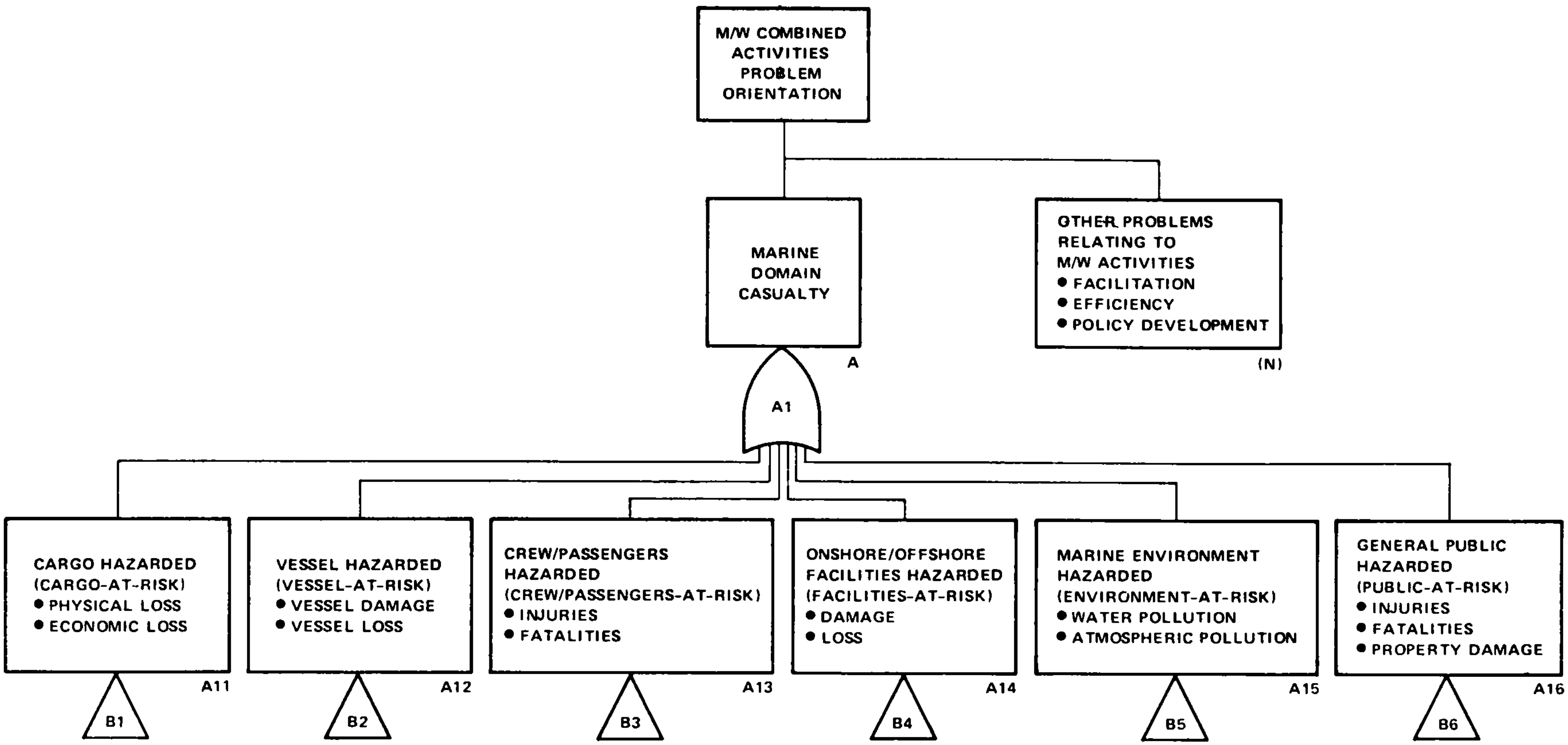


FIGURE 2. TOP LEVEL DISSECTION OF A MARINE DOMAIN CASUALTY – PARTIES-AT-RISK

Event A was partitioned through an OR gate into six subevents. Each of them denoted a set of events creating hazard for a particular element of the marine domain. These, then were the "parties-at-risk" in the event of a marine domain casualty. It was intended that this breakdown be comprehensive, that is, by definition, all of the risked elements of the marine domain were included in one of these six events.

2.2.1.1 Cargo-At-Risk Event. This event subsumes all causes leading to danger of damage or loss to cargo carried in commercial vessels. Casualties to vessels and facilities which destroy the integrity of the cargo containment system are, of course, included. Also included are events leading to loss or deterioration of cargo through contamination, theft, physical loss overboard, etc. By implication, the inclusion of cargo as a party-at-risk in this study suggests that the protection of marine cargo is independently a Coast Guard objective. Coast Guard participants in this project generally agreed that this implication is acceptable although the Coast Guard has traditionally been concerned more with the physical safety of the cargo than its economic integrity. Also, past concern has been largely with cargo as a source of hazard rather than with protecting cargo for its own sake. However, a strong trend in this direction is in force now; the decision of the participants was to include cargo as a full party-at-risk in the RDT&E plan design.

2.2.1.2 Vessel-At-Risk Event. This event includes all factors that could cause destruction or damage to vessels. As will be shown later, these were ordered into groupings under the traditional vessel casualty nomenclature: collisions, rammings, and groundings; structural failures; flooding, capsizing, and foundering; and fire/explosions.

2.2.1.3 Crew/Passengers-At-Risk Event. This event is concerned with all persons involved in some way with operations in the marine domain. Not included are members of the general public--bystanders--not functioning as participants. The causes of the hazard conditions include casualties of various kinds and occupational hazards.

2.2.1.4 Facilities-At-Risk Event. The term "facilities" is meant to include all fixed, artificial structures in the marine domain. Obviously this includes ports (docks, wharves, cargo handling equipment, warehouses, etc.), offshore platforms and ports of all kinds, bridges, locks, and a large variety of other items. Facilities are hazarded mainly by the possibility of structural failure or by fire/explosion casualties, or rammings by vessels.

2.2.1.5 Environment-At-Risk Event. The Coast Guard's responsibility for protection of the marine environment was defined in a series of Public Laws of recent vintage. This is the newest of the Coast Guard's general responsibilities and probably the one generating the greatest public attention now. In this study, the broadest interpretations of what constitutes the marine environment were used. Briefly, it includes the entire aquatic domain plus the contiguous atmospheric one and the shore structure both natural and artificial. Hazards to both ecology and natural resource content of the environment are recognized. As a generalization, there is only one cause of significance in this party-at-risk category: an uncontrolled release of damaging material to the environment. However, this can happen in many different ways--the subproblems developed in connection with preventing and controlling spills are varied and complex.

2.2.1.6 Public-At-Risk Event. This event includes all causes in the marine domain that create hazards for the general public and its property. A typical example of this hazard category is the bridge ramming that damages the bridge, destroys private cars on it, and injures or kills individuals crossing it at the time of the casualty. Another example is the release of gaseous toxic material from a barge which has suffered a collision while transiting an inland waterway. As can be seen, the causes of this hazard condition lie in all the casualty types called out with respect to the other party-at-risk groupings.

2.2.2 Identification of Primary Problem Areas

The next step in the problem dissection process was probably the most significant one as far as the design of the RDT&E plan was concerned. It involved continuing the problem dissection process to a depth sufficient to reveal "primary problem areas". Fourteen of these were identified in the final listing developed at the Planning Conference--an expansion from the list of nine in the prior CVS plan. This expansion resulted from the broader scope of this integrated plan. Of the 14 primary problem areas, 13 were developed out of event A, Marine Domain Casualty, by the problem dissection process. The fourteenth is a different type of primary problem area having to do with the need to analyze and define future marine safety problems and the risks associated with them, and to provide for the development of supporting data bases and information systems.

2.2.2.1 Marine-Casualty-Related Primary Problem Areas. The term "primary problem area" designates a unique, generic type of systemic failure or accident having two characteristics: (1) it is equivalent to a marine domain casualty and (2) it involves a single sector of technology within which a coherent set of hazard control actions can be organized. The conjunction of these two characteristics makes possible an assessment of the effectiveness of the hazard control actions in that set in terms of their potential for reducing or mitigating the occurrence of the marine domain casualty involved. Because they are technologically coherent and provide a logical structure for assessment, primary project areas provide the basic organizational structure for the design of the RDT&E plan. This is the reason this step was cited above as being of critical importance to the design of the plan.

An example of a primary problem area is "occurrence of fire/explosion". It is a generic type of accident occurring in vessels and facilities and it involves a definable technology. A coherent fire control activity can be organized and its effectiveness measured as a reduction in fire/explosion related losses. Other examples of primary problem areas are "vessel collisions, rammings, or groundings", "inability to make timely identification of polluting spills", and "material containment system failure". Examples of nominees that did not qualify as primary problem areas are "human factors faults" and "sabotage". The former of these does involve a definable technology but it is not, in itself, directly equivalent to a marine domain casualty--it functions instead as a cause of many different kinds of such casualties. The latter failed to qualify in both respects.

Figure 3 shows the logic diagram developed to the level of detail at which all the primary problem areas were identified. The drafting of this figure follows the conventions and notation described in Figure 1 except for three additional items of notation. First, primary problem areas are indicated as double-edged boxes wherever they are first generated in the developments of the party-at-risk events. Second, each primary problem area is assigned a two-digit number running roughly in sequence across the diagram starting with 02, "harmful effects of materials" and continuing through 14, "non-marine-casualty-related discharges". (The number 01 is reserved for a different purpose to be discussed later.) Third, primary problem areas are repeated as subordinate events in many locations in the upper part of the diagram; these repetitions are indicated by showing the event symbols with a dotted boundary line. The diagram is developed in this figure far enough to include every such repetition that occurs in the problem dissection process.

In most cases the primary problem areas act as first causes of the party-at-risk events, that is, they appear at the level immediately below them through an OR gate. The vessel-at-risk event (A12), for example, dissects into four casualty events identified with traditional nomenclature and numbered as primary problem areas 05 through 08. Similarly, event A14, "facilities-at-risk", dissects into three casualty events but, in this case, only two are "new" primary problem areas uniquely developed out of event A14: "facility structural failure" and "facility fire/explosion". (Because of their technological similarity with the equivalent vessel casualties, these two primary problem areas were merged with the vessel casualties in setting up the RDT&E plan so they are numbered (06) and (08) respectively.) The other event developed by dissecting A14 is numbered B41. This event, when developed one level further, generates repeats of the vessel casualty set of primary problem areas.

The first cause character of the primary problem areas is clearly manifested in the developments of party-at-risk events A11, A12, A14, and A16; albeit, in the last case no "new" primary problem areas were revealed in the development--all are repeats. In the cases of events A13 and A15, however, the primary problem areas are identified several levels down and do not appear to be functioning as first causes. In fact, they <u>are</u> first causes but in these two cases, the problem dissection logic indicated an ANDed relationship among the

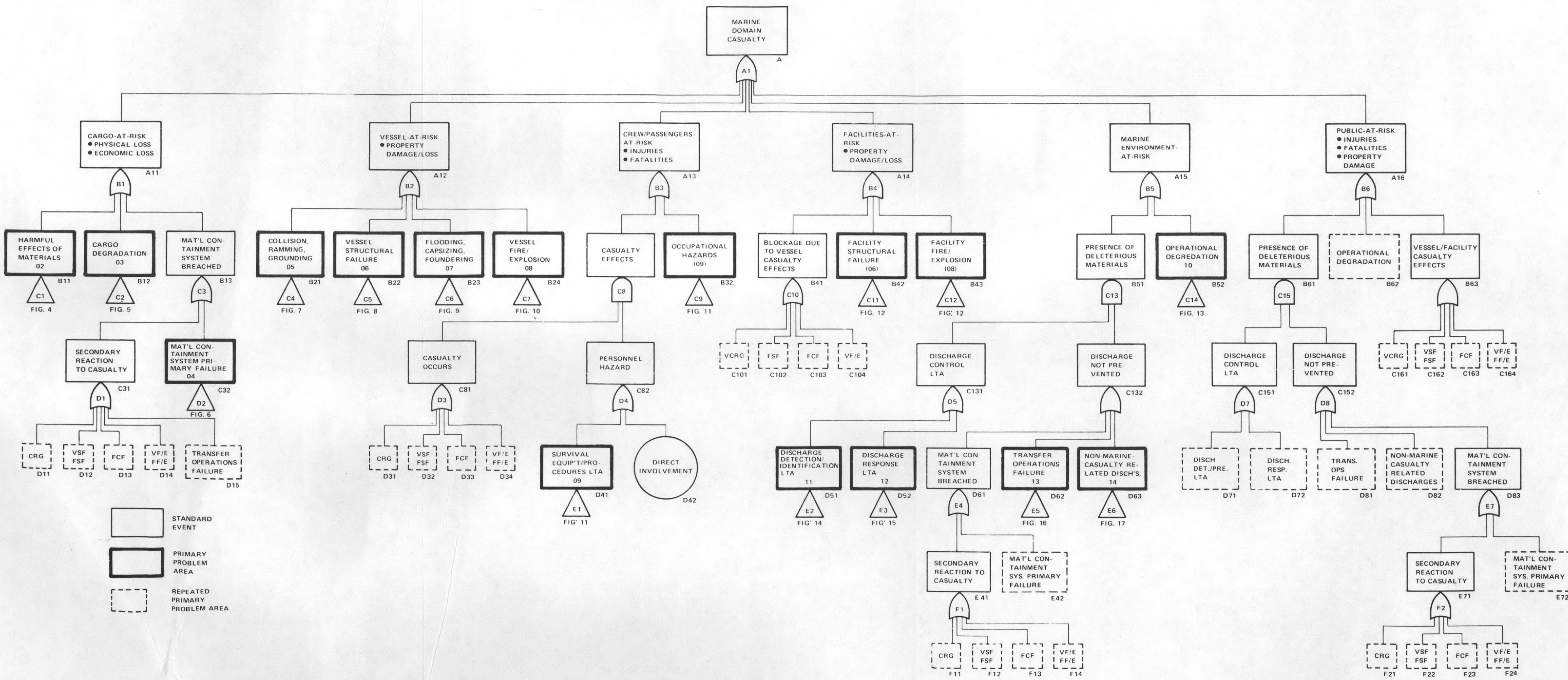


FIGURE 3. PRIMARY PROBLEM AREA LOGIC DIAGRAM

cause events; it was necessary to interpose some continuity events such as C81, "casualty occurs", in order to describe the event chains accurately.

Three events, B32, D41, and D42 require separate explanation. In the case of B32, "occupational hazards", the event was identified as a primary problem area as was D41, "survival equipment and procedures less than adequate". Because of their technological similarity, these two events were merged into one primary problem area numbered 09. Event D42 is a "basic" event; this means it ends the development of its branch of the D4 logic gate. Further subproblem development of this branch was judged meaningless because no RDT&E-susceptible subproblems were implied in its development.

2.2.2.2 Problem Analysis Primary Problem Area. As noted earlier, this problem area was not identified as a result of the partitioning process. Rather, there was a recognition, as the partitioning process was carried out, that certain generic problems common to all the primary problem areas were implied at all levels of the diagram. These common problems had to do with three basic topics:

(1) The need to define future marine safety problems and assess the risks involved. This need was based on the realization that if the Coast Guard's safety program is to be a dynamic one, it must be able to anticipate the problems of the future and their relative importance.

(2) The need to establish a methodology whereby the Coast Guard can make formalized assessments of the risks attending various aspects of marine domain activities. With this methodology, the impact of different regulations/services packages on these risk levels could be measured as inputs to Coast Guard command decisionmaking.

(3) The need to provide a coordinated system of information about all aspects of marine safety as a basic tool for all elements of the M and W Offices.

These problems are not specific to any particular type of marine domain casualty but are vitally important elements of the overall problem array. In view of this, the decision was made to create a primary problem area entitled "Problem Analysis, Definition, and Management Information Problem Area", with the number 01 assigned.

2.2.3 Subproblem Analysis

The top-level event shown in Figure 3 are not sufficiently disaggregated to reveal casualty causes which can be defined as subjects for RDT&E efforts. However, by subdividing further, more detailed causes can be identified--in fact, one can, in theory, carry the process down to the level of individual component failures. Such a process is the most direct way to discover and present combinations of possible causes of casualties, hence, to reveal possible areas of RDT&E activity. The process of logical subdivision is also useful in that it shows the sequence of linkages relating a type of accident to its combination of root causes. This can provide a basis for evaluating the utility of an effort to eliminate some one of the various event possibilities that can result in an accident.

Each of the primary problem areas (with the exception of the first one described above) was developed further in logic diagram form. A full diagram was generated for each one; each was carried to the level of detail at which the opportunities for RDT&E efforts were judged to be clarified by the revelation of problems considered RDT&E-susceptible. As noted previously, the choices of which problems met this criterion were affected by many different factors the most important of which were: (1) the project nominations coming out of the Planning Conference, (2) the plans for RDT&E effort already developed by the program offices and divisions in the W/M domain, (3) the content of the predecessor CVS plan, and (4) the judgment of the study team.

The diagrams were drawn exclusively for the purpose of spotting likely RDT&E project areas. They are, therefore, representations of generic types of accident-causing events intended to help identify and flag problems that may arise in the future as well as record those that appear at present. The diagrams were not intended to be--and are not--complete engineering diagnoses of the physical causes of particular past or present marine domain casualties. No doubt many branches are missing; those shown were deliberately simplified at many junctions by citing general classes of casualties rather than itemizing details composing the classes. Nonetheless, they comprised a useful representation of the scheme of thinking by which R&D topics were identified and established a pattern for evaluation.

Most of the logic diagram branches, in the figures to follow, are truncated at levels aligned with the "project" level of the RDT&E plan structure. This structure is discussed later in the "Plan Structure" section of this report. Diamond symbols, as described in Figure 1, are used at most of these truncation points to indicate that the branch developments are arbitrarily ended at those levels since further development would not have contributed useful additional knowledge for plan design. The diagram element numbering system begun in the Figure 3 diagram is not carried beyond the top box and logic gate in these detailed diagrams as in this analysis they are useful only as locators of the detailed diagrams.

2.2.3.1 Problem Area No. 02, Harmful Effects of Materials. The basic subproblem addressed in Figure 4 is absence of sufficient knowledge about the characteristics of the materials. This lack of knowledge leads directly to their being allowed to inflict damage on themselves, other materials in the system, or on the environment when casualties or mismanagement occur. The primary problem is subdivided into three subproblems, each denoting a field of knowledge vital to the safe management of materials. The main emphasis in this definition of subproblems is on materials as cargoes in marine commerce, but the scope addressed in the subproblem array is not confined to cargoes--it includes all materials stowed and/or utilized in the marine domain.

2.2.3.2 Problem Area No. 03, Cargo Degradation. This problem area is concerned with loss or economic degradation of cargo by means other than casualties in the cargo containment system (covered in primary problem area number 04). The logical partitioning of this problem area, shown in Figure 5, is not complex. Degradation can occur as physical loss of the cargo by the means shown in the third-level subdivision, or by allowing conditions to exist that cause a change in the cargo's state or condition, e.g., allowing a tankload of molten chocolate to cool and solidify thus making it useless for food processing at the destination port.

2.2.3.3 Problem Area No. 04, Material-Containment-System Primary Failure. The basic casualty analyzed in this diagram, Figure 6, is breaching of the containment system as a primary failure so that an uncontrolled emission

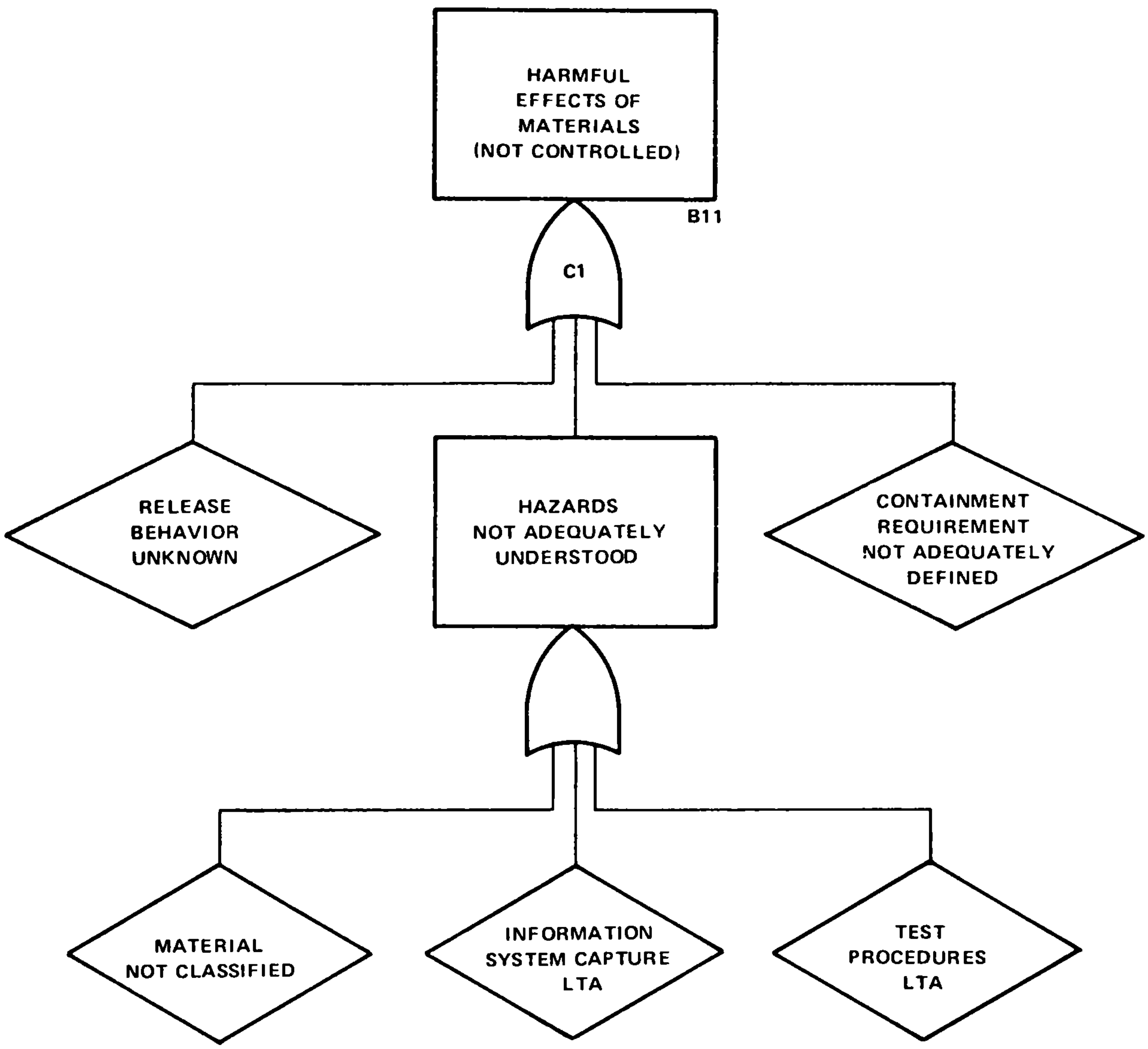


FIGURE 4. LOGIC DIAGRAM FOR PROBLEM AREA 02, "HARMFUL EFFECTS OF MATERIALS"

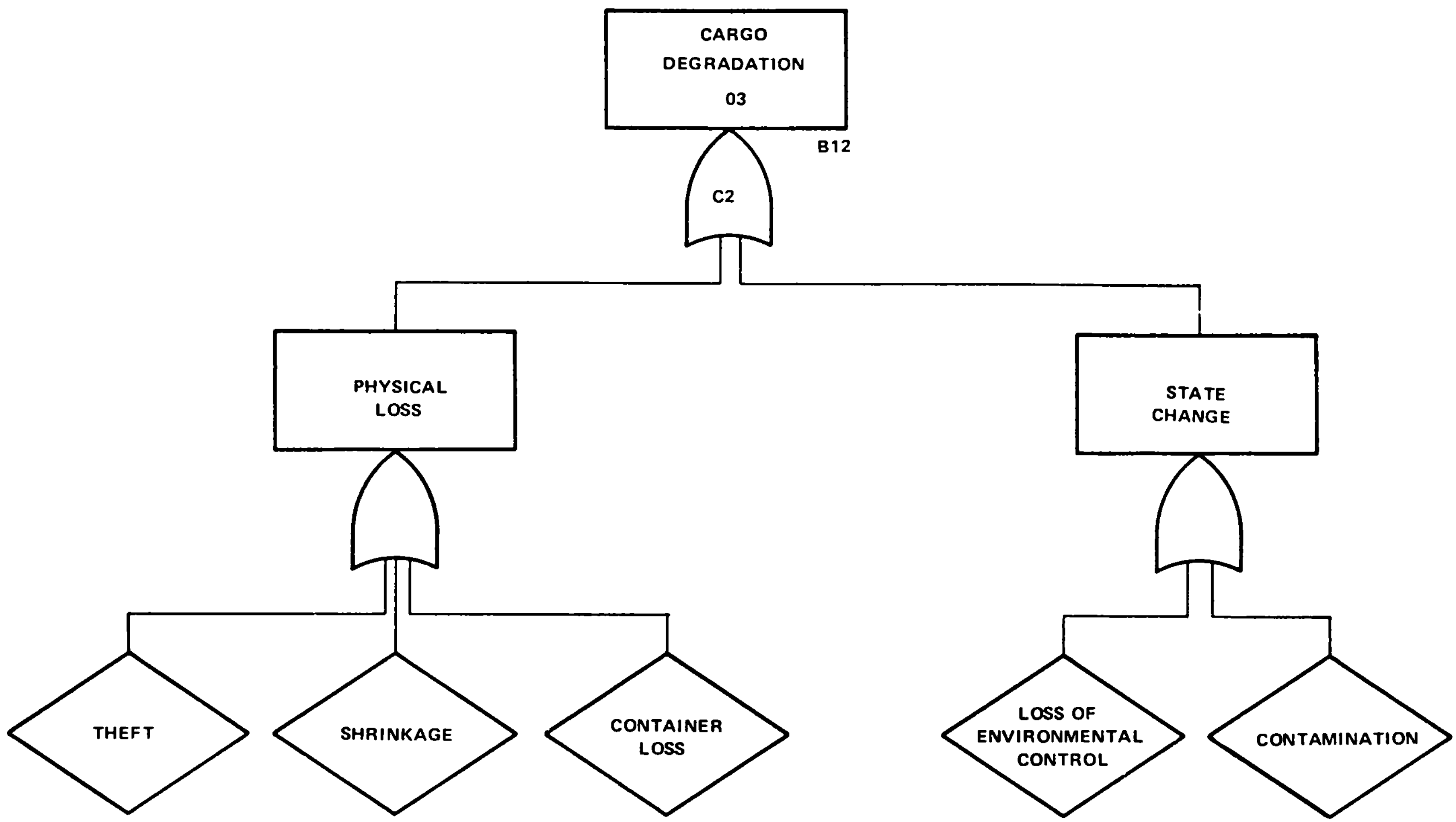


FIGURE 5. LOGIC DIAGRAM FOR PRIMARY PROBLEM AREA 03, CARGO DEGRADATION

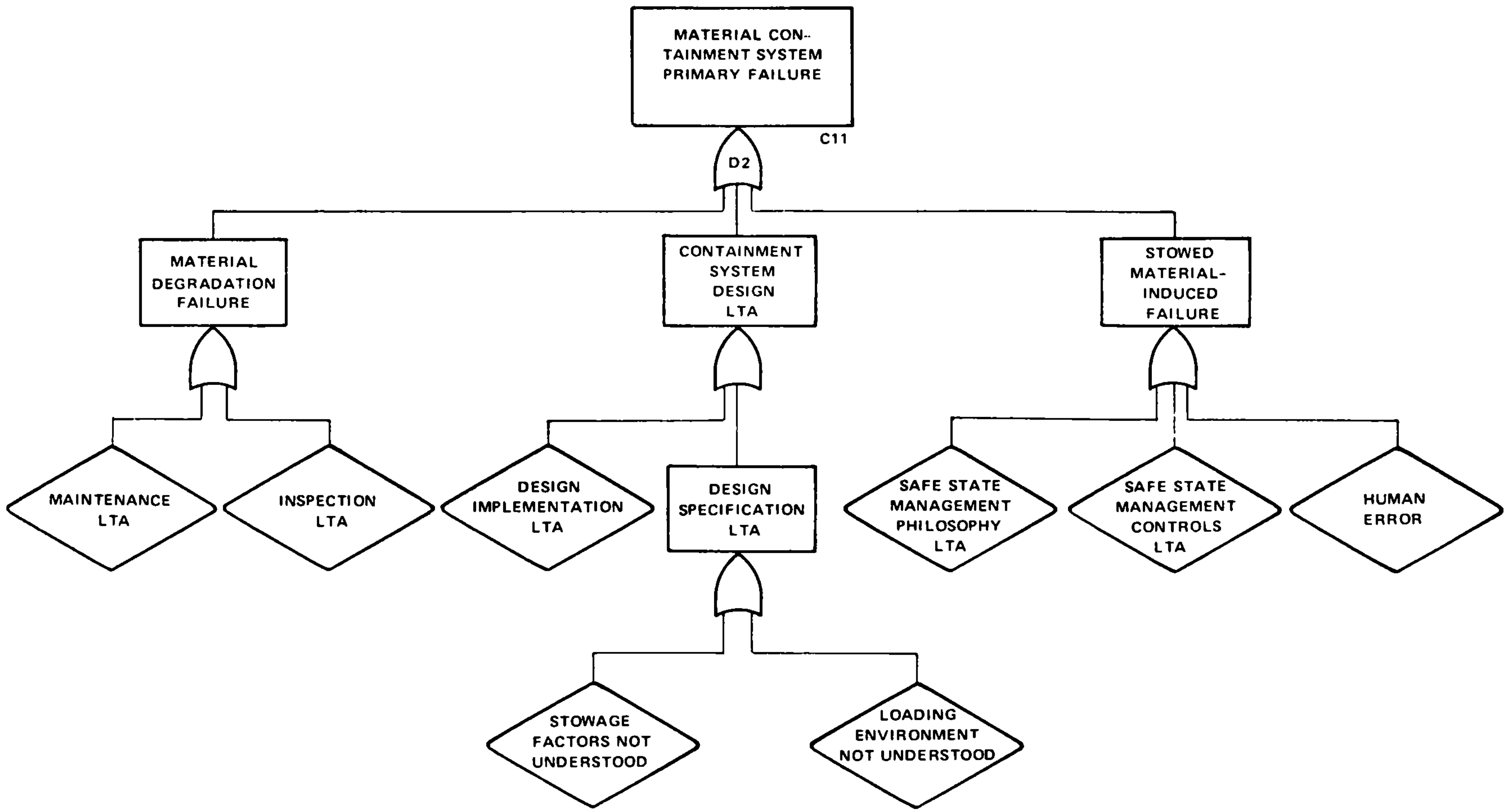


FIGURE 6. LOGIC DIAGRAM FOR PRIMARY PROBLEM AREA 04, MATERIAL CONTAINMENT SYSTEM PRIMARY FAILURE

of the contained material occurs. As in the case of problem area 02, the main concern here is with cargo, but the problem definition is not limited to cargo per se, hence the nomenclature "hazardous material" is used in naming the problem area.

The casualty is portrayed as being caused by any combination of inadequacies in design of the system, the way in which it was maintained, or control of the state of the material in stowage. Third- and fourth-level partitions of these problems are defined.

2.2.3.4 Problem Area No. 05, Collisions, Rammings, or Groundings. The problem partitions in this diagram, Figure 7, emphasize the branch concerned with the sources of imbalances among vessel navigation capabilities. The basic problem was subdivided into vessel response, navigation information, and human controller subproblems. Damage mitigation possibilities were recognized by combining them with the casualties under and AND gate.

2.2.3.5 Problem Area No. 06, Vessel Structural Failure. The problem addressed in Figure 8 is the structural breakup of a vessel as a primary failure. It can, of course, occur as a secondary result of other marine casualties; this is recognized in the diagram. However, the main concern is with design and materiel problems.

2.2.3.6 Problem Area No. 07, Flooding, Capsizing, Foundering. This problem area is mainly concerned with vessels, but the logic diagram, Figure 9, is designed to include coverage of the stability problems that may occur with floating wor platforms as well as the more conventionally formed vessels. The main hazard being revealed in this diagram is that vessels may be in the process of being developed with inadequate understanding of their stability and sea-keeping characteristics. This would conceivably lead to the situation of vessels being at sea with unknown hazards relative to their ability to handle all the types of sea conditions to which they might be subjected. These problems are developed in the left branch of the diagram. The right branch deals with casualty-related stability problems including that of defining adequate damage stability in vessels. The far right event "intentional foundering" was included in the diagram for completeness; no RDT&E-susceptible problems were identified in connection with it.

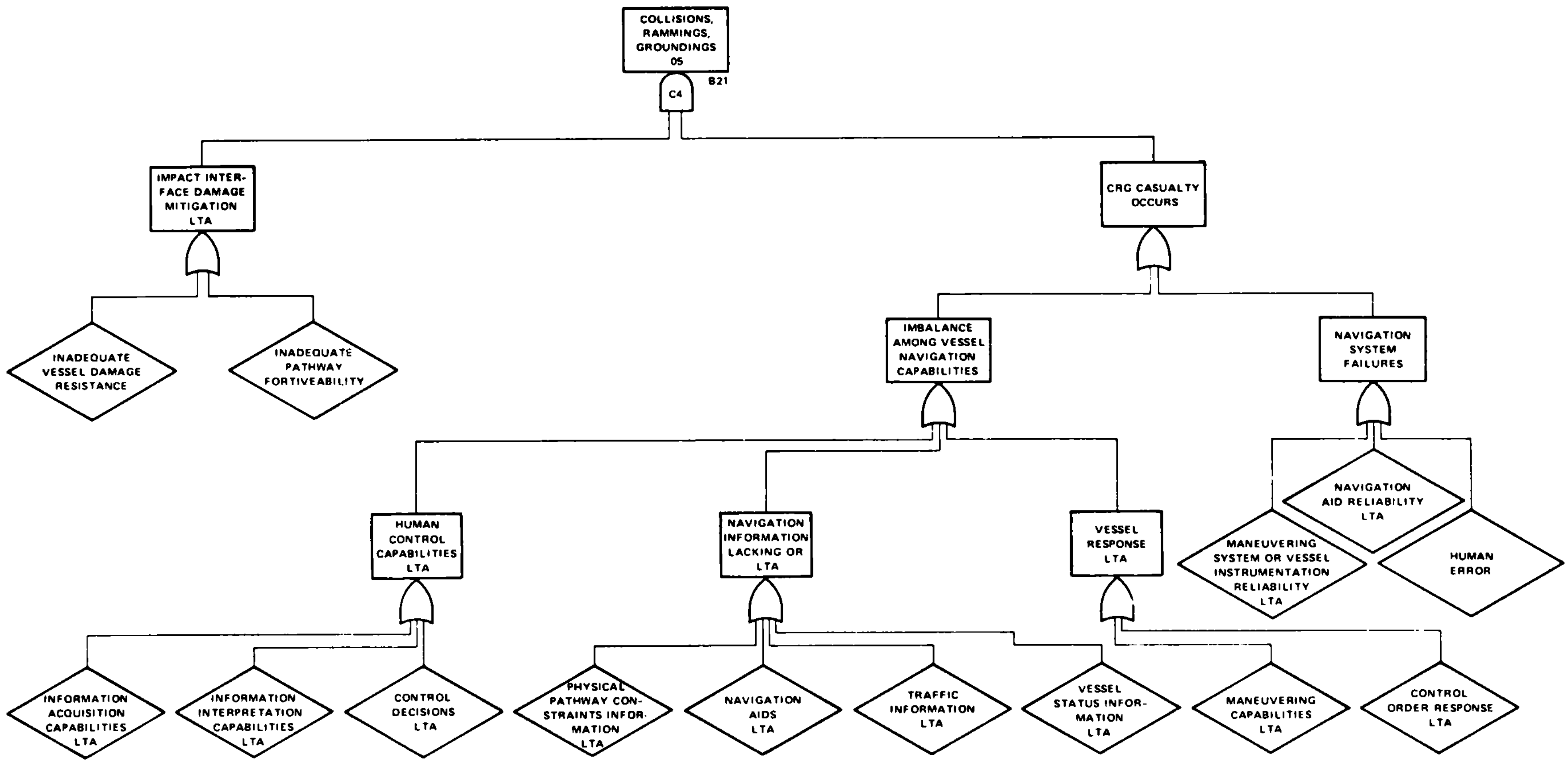


FIGURE 7. LOGIC DIAGRAM FOR PRIMARY PROBLEM AREA 05, COLLISIONS, RAMMINGS, AND GROUNDINGS

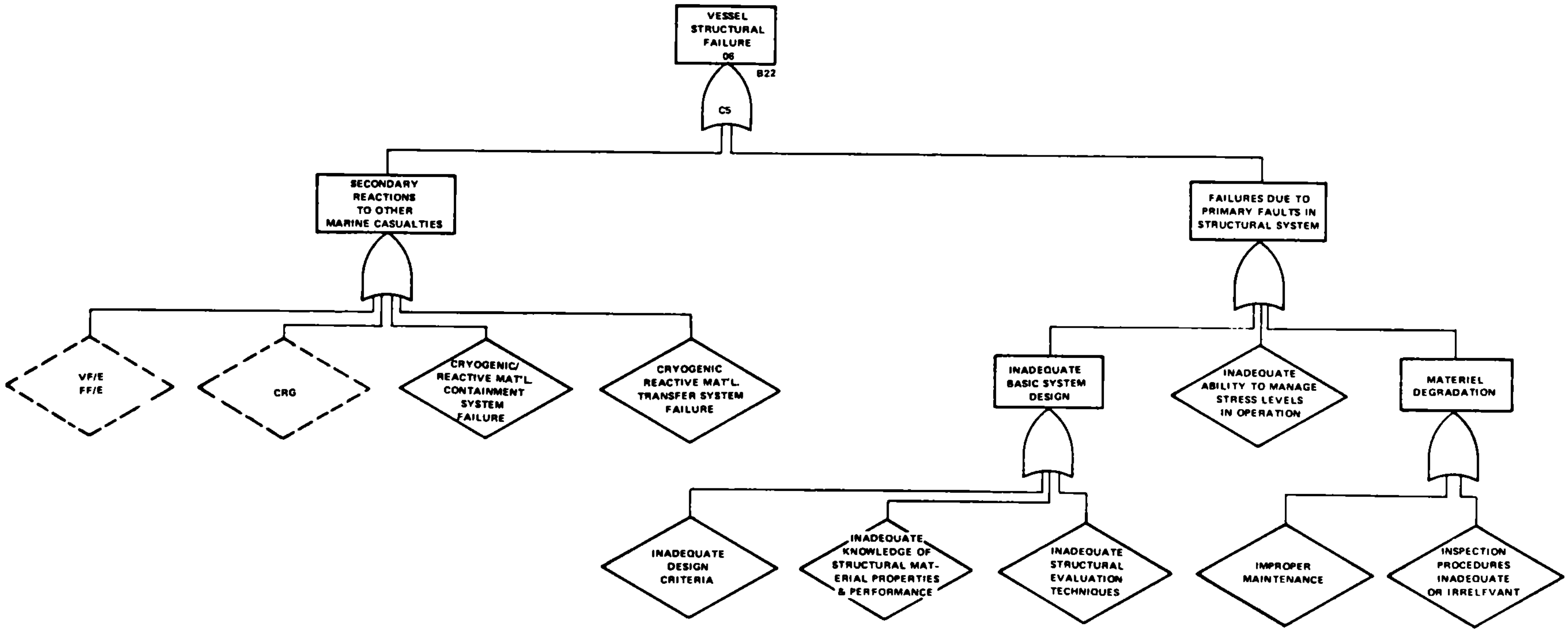


FIGURE 8. LOGIC DIAGRAM FOR PRIMARY PROBLEM AREA 06, VESSEL STRUCTURAL FAILURE

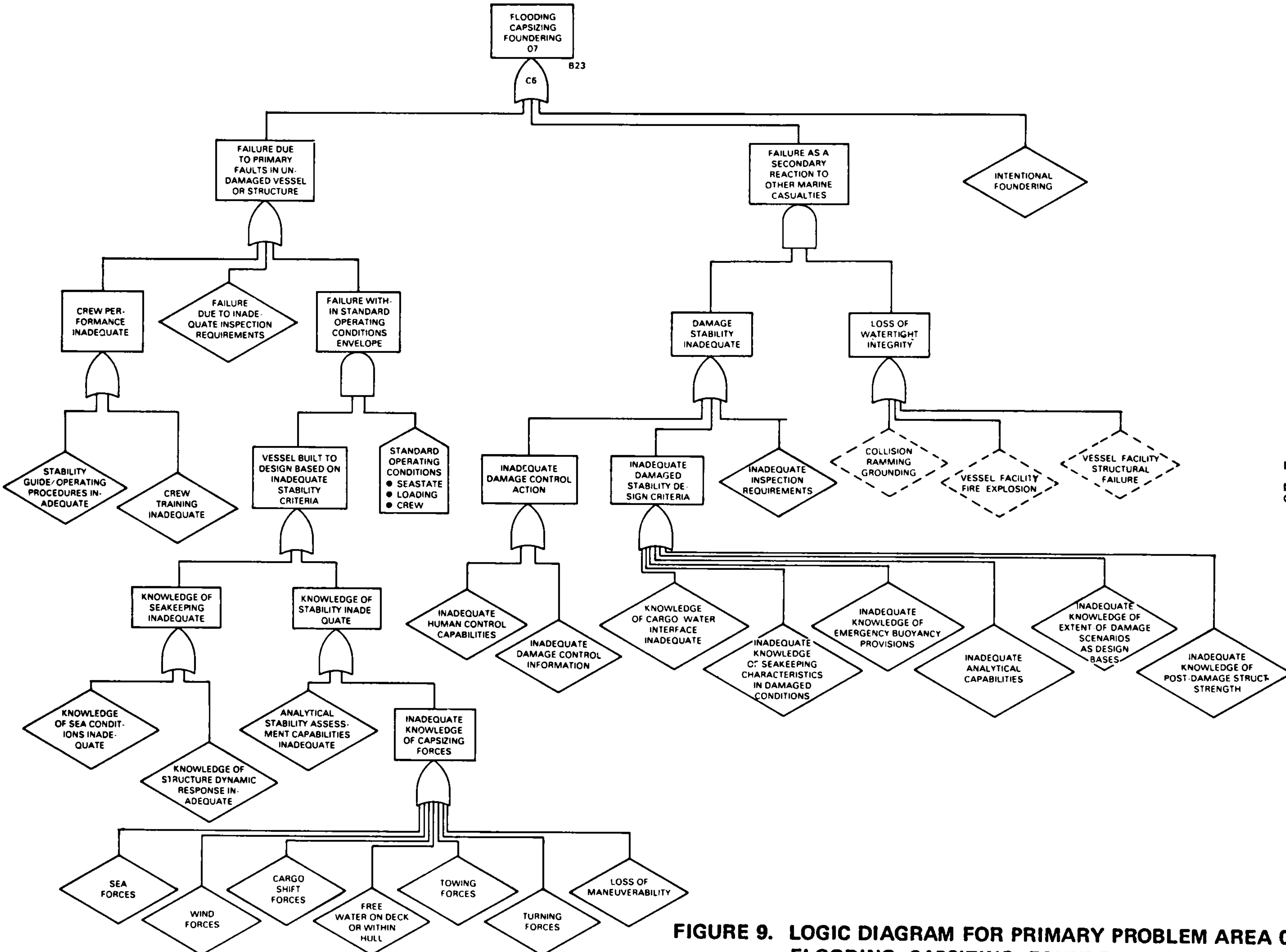


FIGURE 9. LOGIC DIAGRAM FOR PRIMARY PROBLEM AREA 07, FLOODING, CAPSIZING, FOUNDERING

2.2.3.7 Problem Area No. 08, Vessel Fire/Explosion. This problem area, Figure 10, is concerned with any type of fire or explosion occurring on vessels. Most of the problem content is partitioned out under the branch concerned with chemical fires or explosions. Subproblems with preventive and control measures are combined under an AND gate. Similarly, causes of ignition and combustible mixtures being present are combined under an AND gate. The structure of this tree is the same as the one developed later for facility fire/explosion.

2.2.3.8 Problem Area No. 09, Crew/Passenger Safety. As noted earlier, this diagram, Figure 11, covers two problem areas: one concerned with survival and one concerned with occupational hazards. To show the combined problem area dissection completely, the diagram repeats most of the party-at-risk portion of the pertinent part of the summary diagram, Figure 3. The occupational hazards shown in this diagram are those considered specific to the marine environment; they do not attempt to catalogue all the industrial hazards faced by crewmen aboard ships, for example, in the marine environment.

2.2.3.9 Problem Areas Nos. (06) and (08), Facility Casualties. As previously noted, these problem areas were combined, for plan design purposes, with the similar vessel casualty areas. A separate logic diagram, Figure 12, was constructed for them, however, so as to identify their unique problems, if any. Some were identified in the structural problems branch as shown. However, the problem development of the fire/explosion branch turned out to be identical to the one developed for the vessel casualty so it was not repeated on this figure.

2.2.3.10 Problem Area No. 10, Operational Degradation. This problem area has to do with degradation of the marine environment as a result of normal operations of various types in the marine domain. Bank erosion from the effect of vessel wakes is a good example of the type of subproblem developed in this diagram.

2.2.3.11 Problem Area No. 11, Discharge Detection and Identification. This is a problem area of major importance in the Coast Guard's performance of its assignment relative to protecting the marine environment. The subproblems,

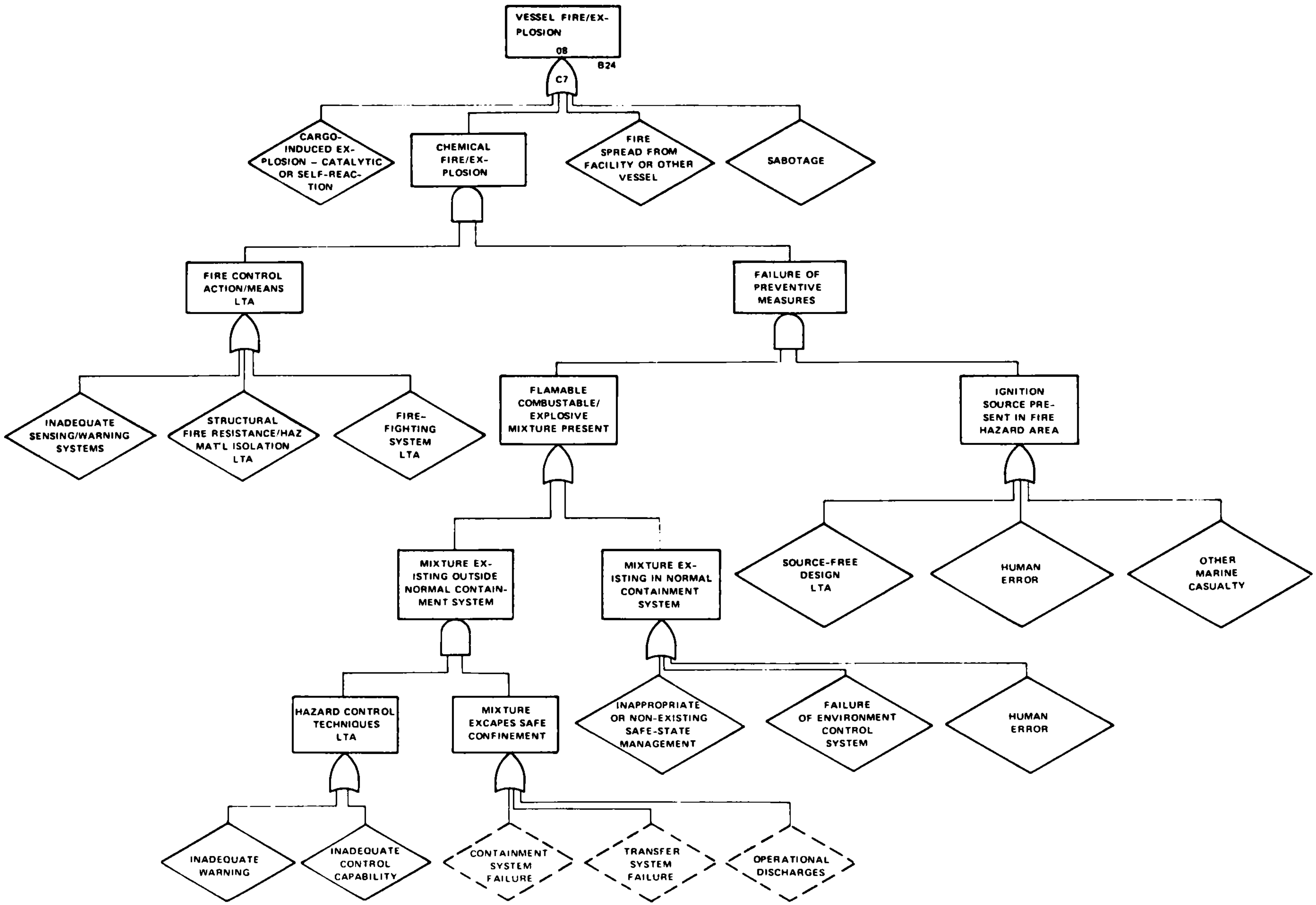


FIGURE 10. LOGIC DIAGRAM FOR PRIMARY PROBLEM AREA 08, VESSEL FIRE/EXPLOSION

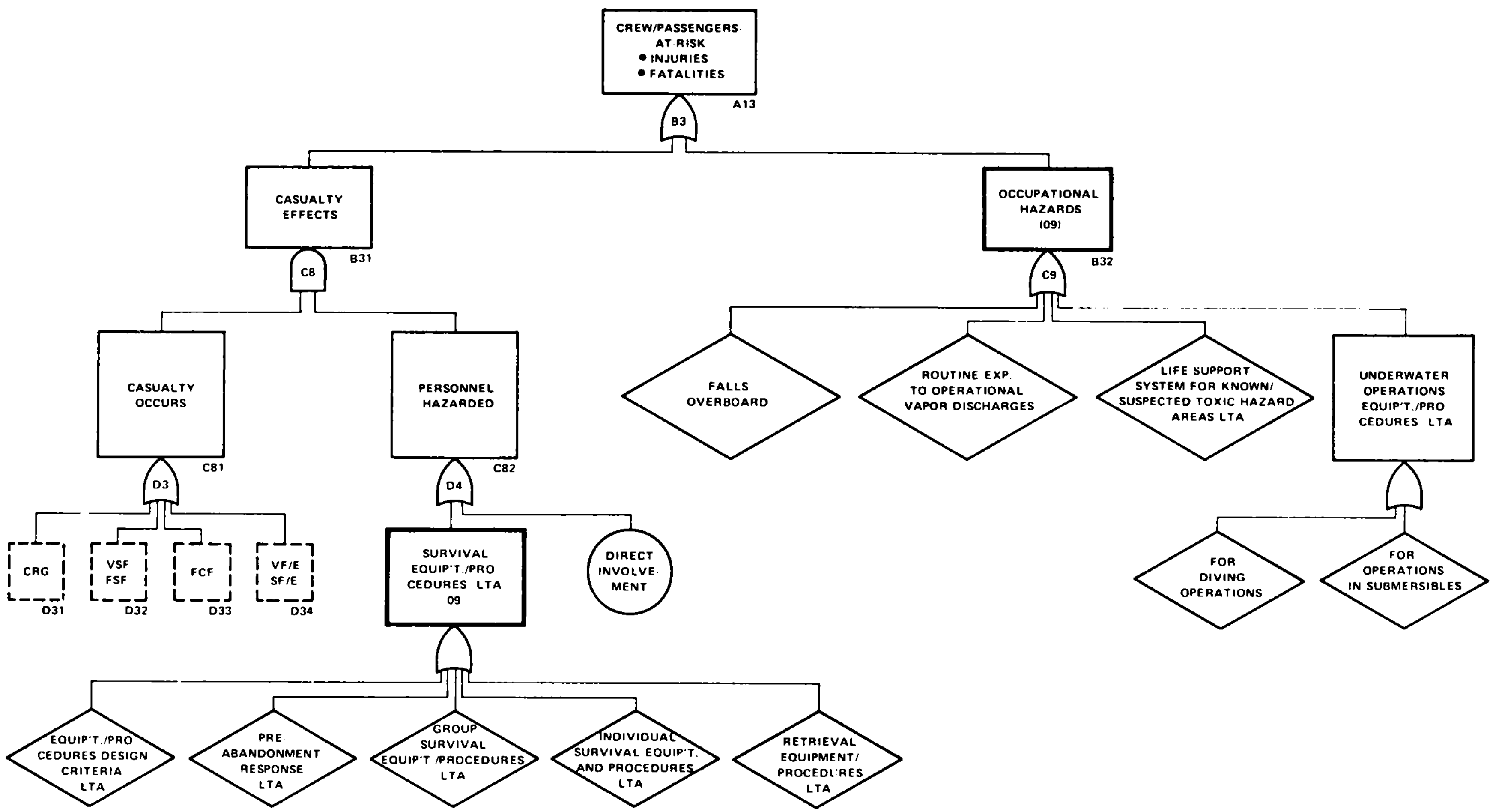


FIGURE 11. LOGIC DIAGRAM FOR PRIMARY PROBLEM AREAS 09 AND (09), CREW/PASSENGER SAFETY

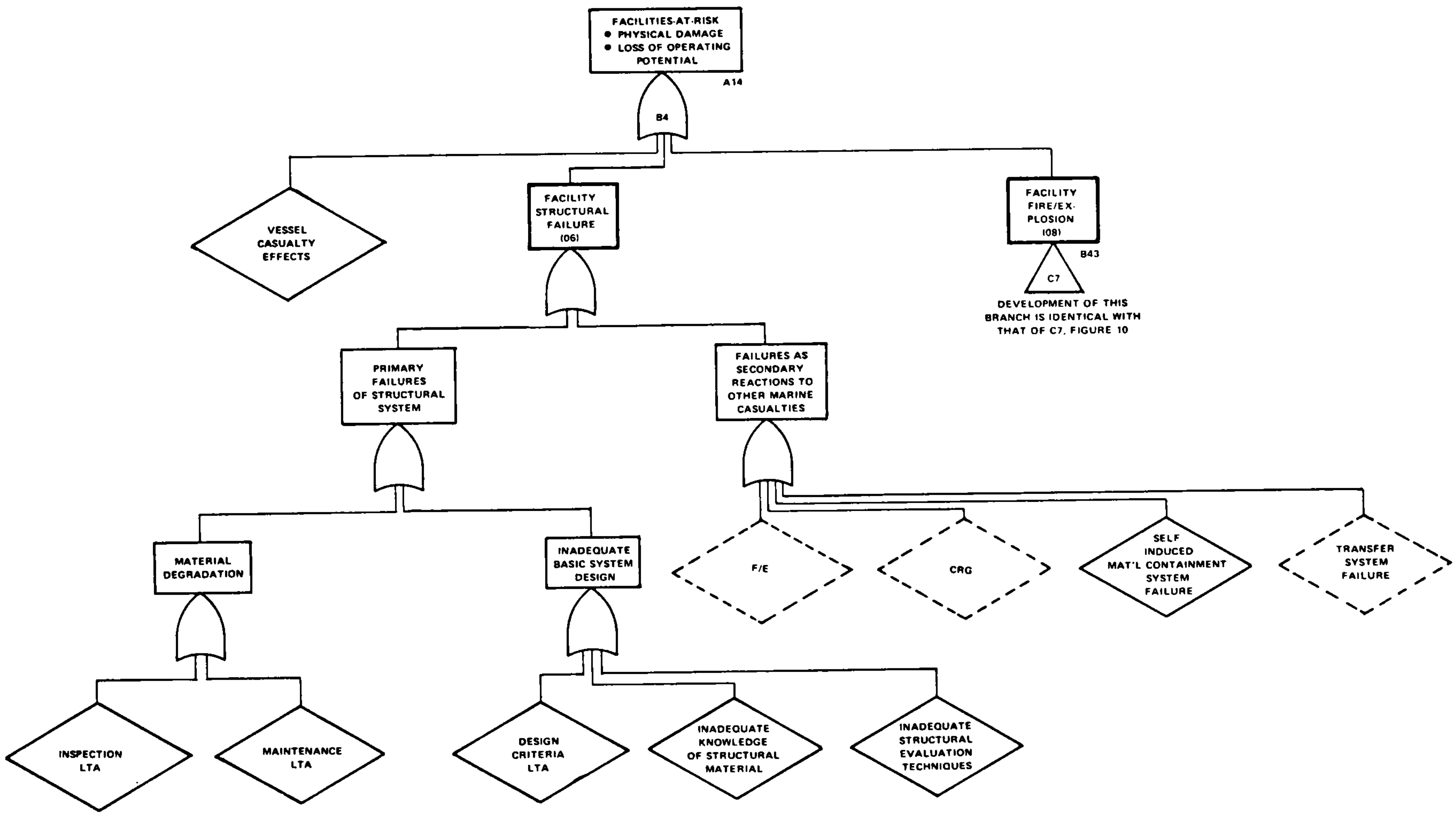


FIGURE 12. LOGIC DIAGRAM FOR PRIMARY PROBLEM AREAS (06) AND (08), FACILITY CASUALTIES

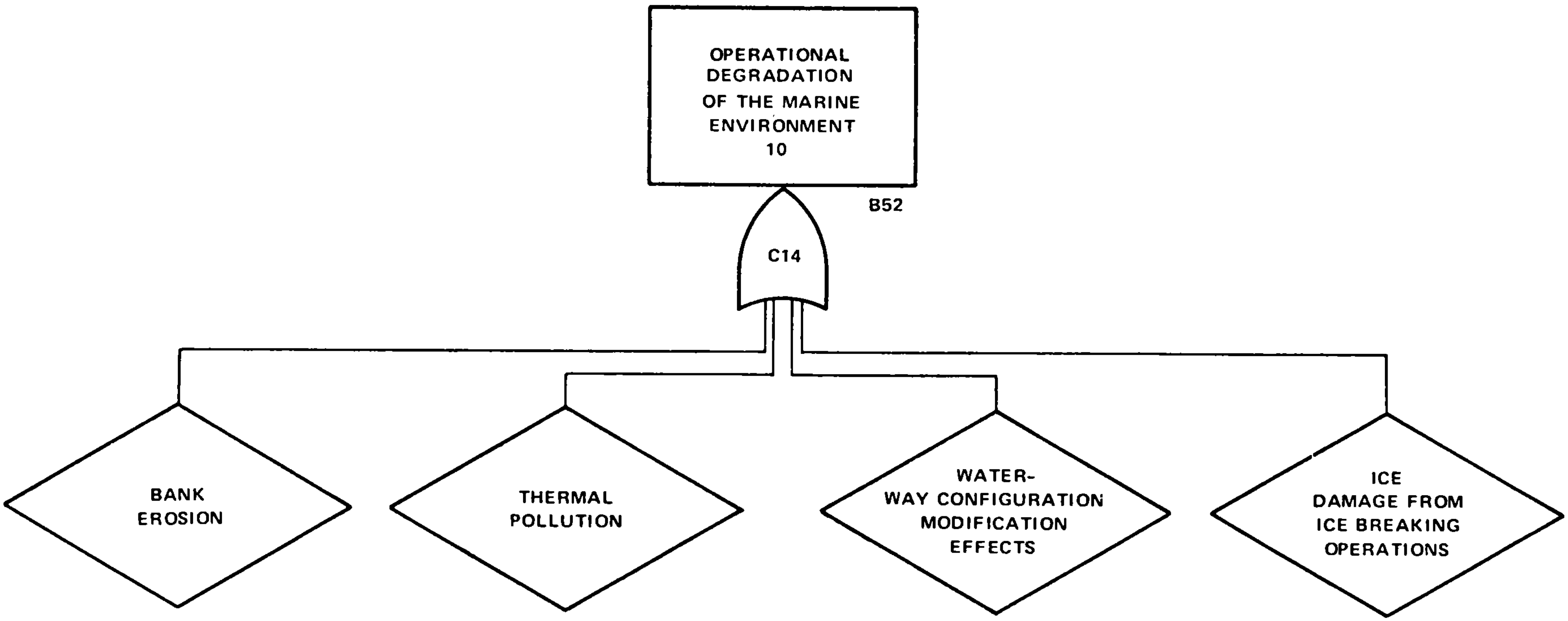


FIGURE 13. LOGIC DIAGRAM FOR PRIMARY PROBLEM AREA 10, OPERATIONAL DEGRADATION

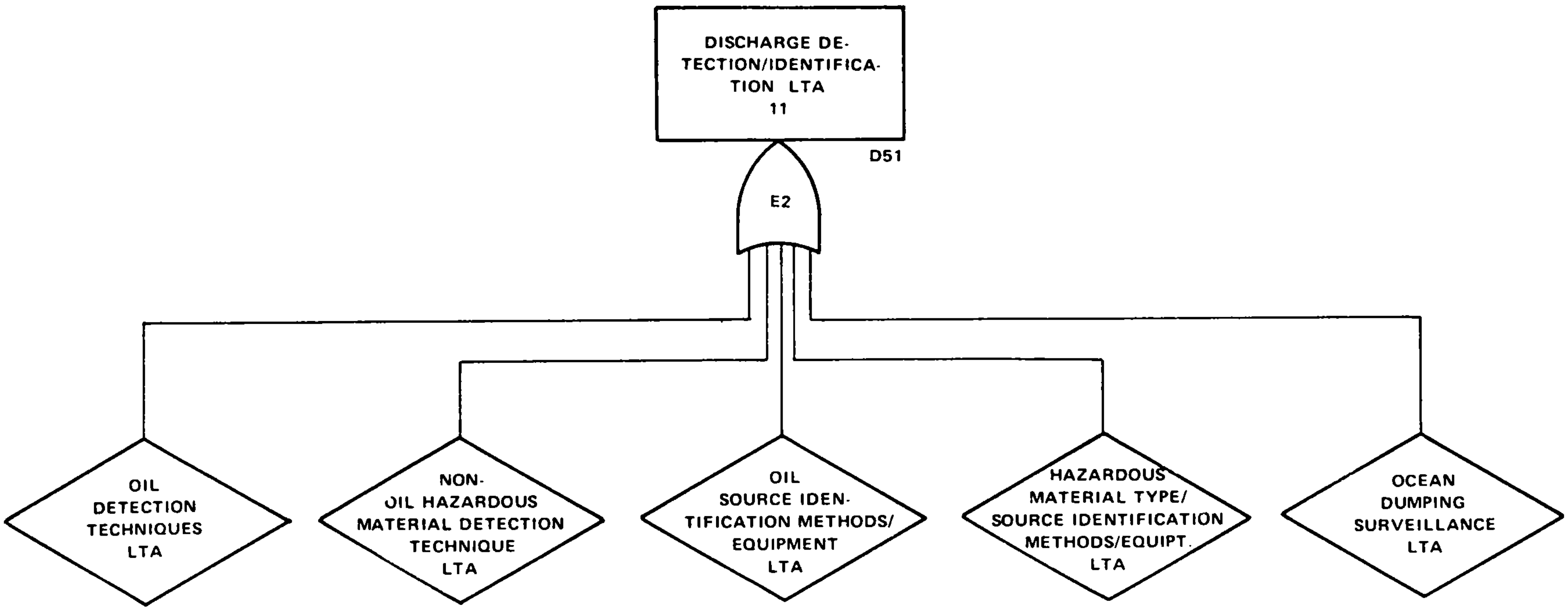


FIGURE 14. LOGIC DIAGRAM FOR PRIMARY PROBLEM AREA 11, DISCHARGE DETECTION AND IDENTIFICATION

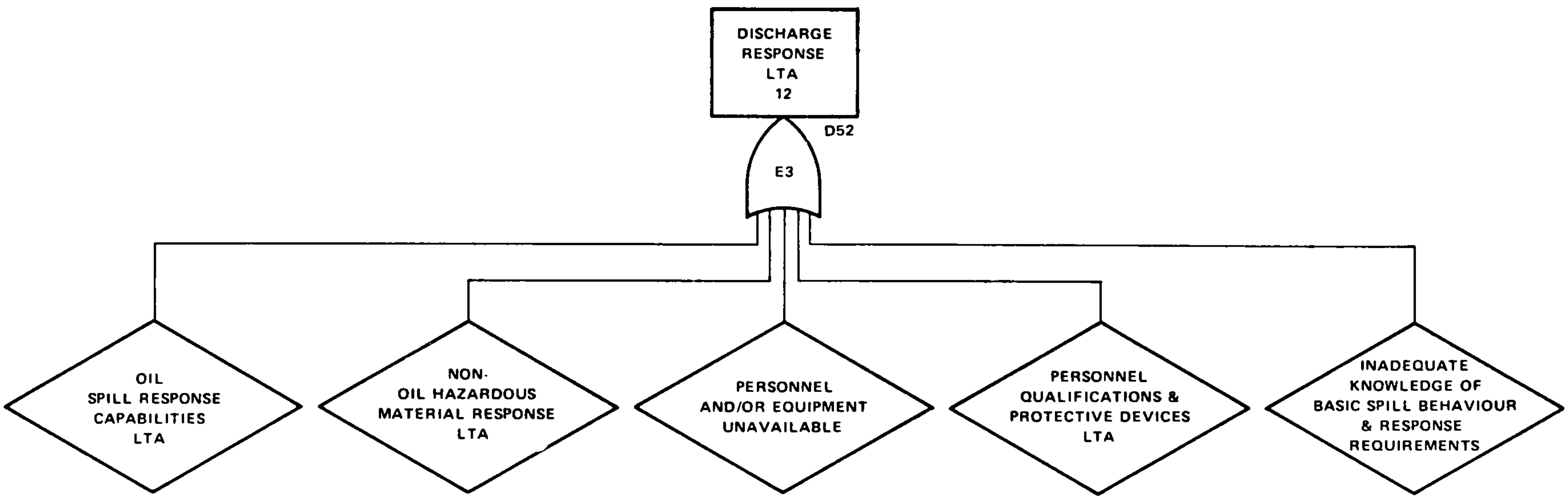


FIGURE 15. LOGIC DIAGRAM FOR PRIMARY PROBLEM AREA 12, DISCHARGE RESPONSE

as shown in Figure 14 are divided into "oil-related" and "other-material-related" problems of detection and identification.

2.2.3.12 Problem Area No. 12, Discharge Response. This problem area is a companion to the one mentioned above; it is directly concerned with the protection of the marine environment. Both have to do with "controlling" a discharge rather than preventing it. The summary diagram, Figure 3, shows these two companion problem areas ANDed with the branch titled "failure to prevent discharge". Although the form of the logic diagram, Figure 15, turned out to be simple in comparison with several others discussed here, the subject is actually most complex.

2.2.3.13 Problem Area No. 13, Transfer Operations Failures. This problem area is concerned with casualties during cargo handling and transfer operations. The emphasis is on casualties that result in spills of hazardous/polluting materials. As shown in Figure 16, the subproblems are partitioned into materiel failures such as bursting hoses or parted cables and failures in control.

2.2.3.14 Problem Area No. 14, Discharges Not Related to Marine Casualties. This problem area, diagrammed in Figure 17, concerns discharges of deleterious materials to the marine environment due to routine operations of any kind. The problem area is subdivided into discharge sources within the marine domain such as vessels discharging sewage products or tank cleaning slops and those outside the marine domain such as shoreside processing plants whose effluent finds its way to the water.

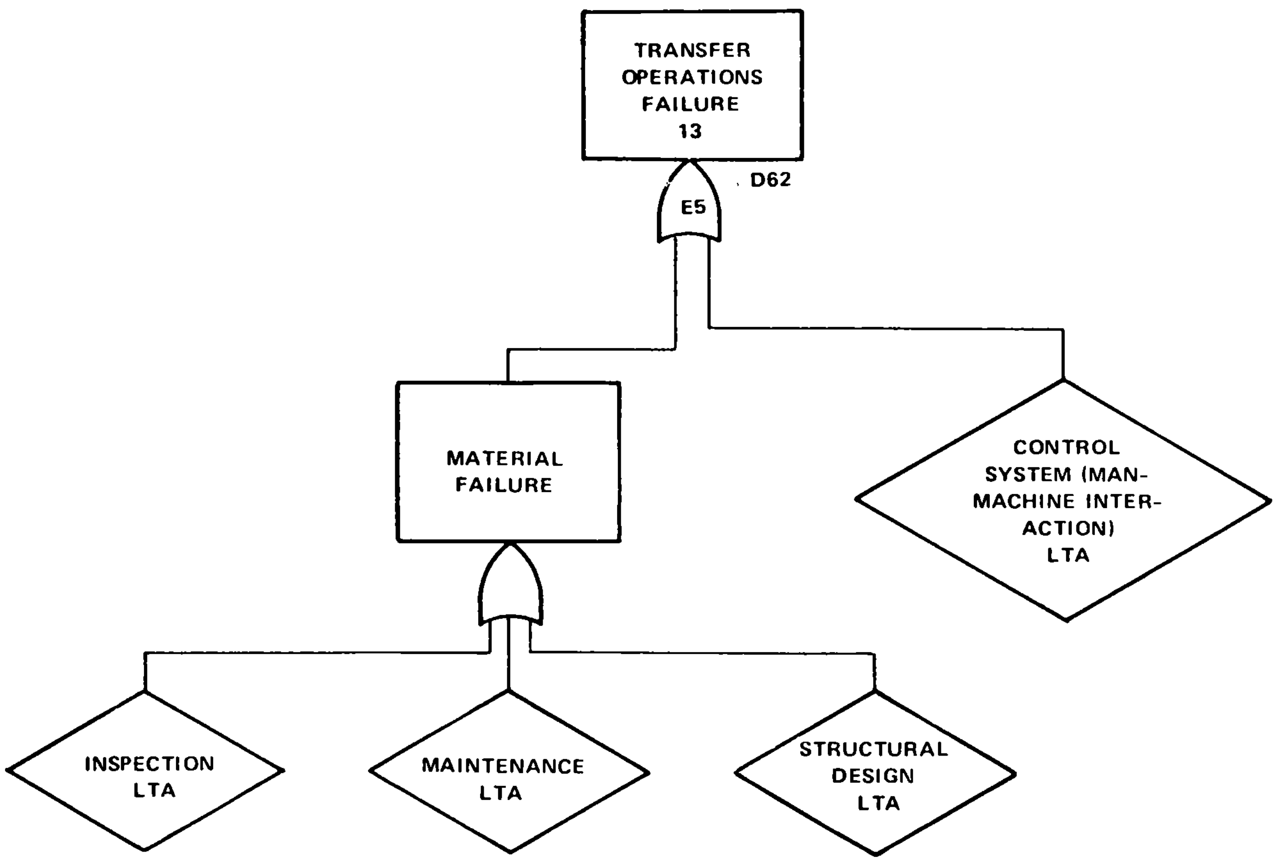


FIGURE 16. LOGIC DIAGRAM FOR PRIMARY PROBLEM AREA 13, TRANSFER OPERATIONS FAILURES

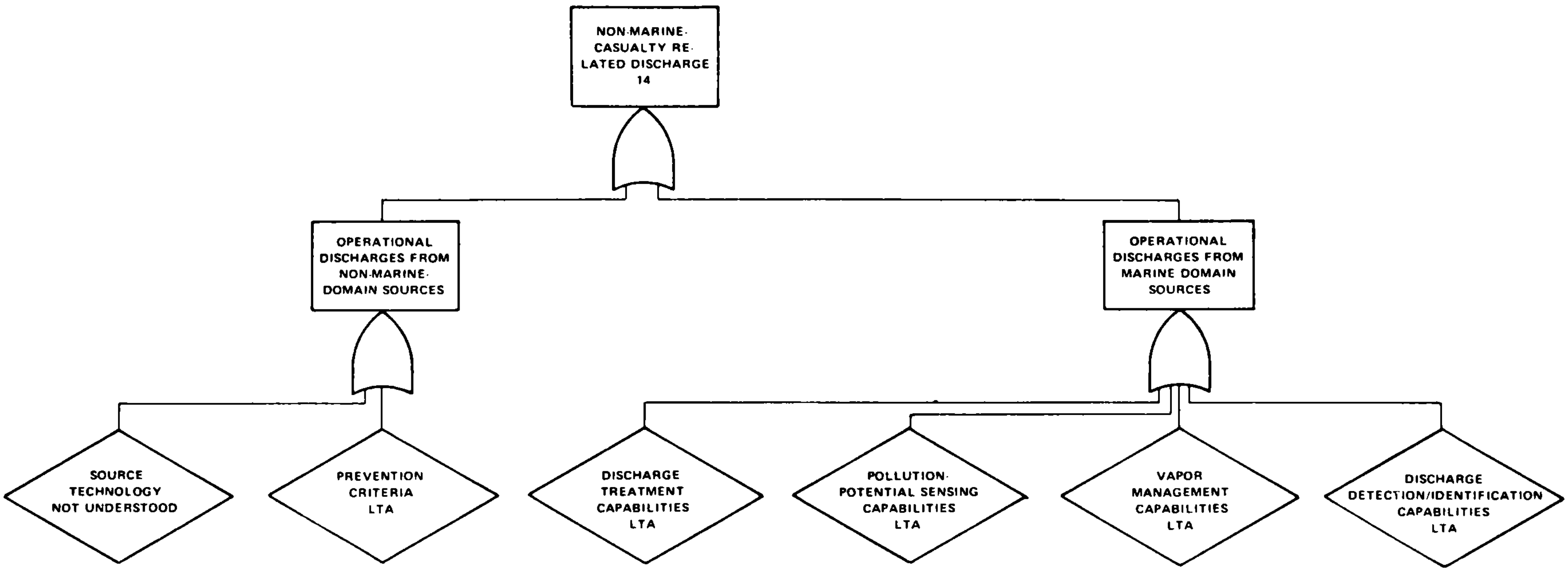


FIGURE 17. LOGIC DIAGRAM FOR PRIMARY PROBLEM AREA 14, NON-MARINE-CASUALTY RELATED DISCHARGES

2.3 RDT&E PLAN STRUCTURE

The RDT&E plan structure was derived directly from the framework of the problem dissection process. The basic structural element was the project area. Each project area in the plan was defined to be the counterpart of a primary problem area. That is, a project area was considered to be a coherent, individually organized set of activities aimed at solving the RDT&E-susceptible part of a primary problem area. Thus, the terms "primary problem area" and "project area" refer to the same thing but from the different viewpoints of problem definition and problem solution, respectively.

2.3.1 Levels of Structure

A three-level structure was chosen for the plan. The elements at the three levels were termed "Project Areas". "Projects", and "Tasks".* As mentioned above, Project Areas are program-type sets of activities aligned with primary problem areas. They are subdivided into projects and projects are further subdivided into tasks.

The projects comprising a Project Area were designed to address individual subproblems revealed in the dissection process. They are individual work units that can be undertaken or deferred without vitally affecting the other projects in a project area. Thus, the output of a project is primarily a solution to an RDT&E-susceptible problem in marine safety, not an input to another project. This is not to say that there are no interrelationships among projects--there are many as will be indicated in the project descriptions later on; but it was intended that there be no projects in the plan whose only purpose is providing inputs to other projects.** The main reason for defining projects in this way is to facilitate measurement of their relative value in accomplishing the plan's goal vis-a-vis controlling marine casualties.

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*This nomenclature is not the same as that used internally in the Coast Guard for R&D administration. This was to avoid possible confusion that might result if this document were interpreted as a functional part of the R&D operation rather than as a resource document which is its intended use.

**An exception to this principle is the projects addressing primary problem area No. 01 "Problem Analysis and Management" described in Section 2.3.2.2; this work is intended to be, in part, supportive of the rest of the RDT&E plan.

The tasks comprising a project are, in general, the sequence of related steps necessary in doing the project. By related steps is meant such things as "conduct a systems analysis", "study and critique the state of the art", and "develop an analytical model". These are necessary, and in some cases very large scale, RDT&E enterprises that can be separately accounted for and undertaken. However, they have significance to the marine safety goals only when their results are combined with those of the other tasks in the particular project; they do not individually solve or mitigate any of the defined problems. Each of the tasks in a project is to be thought of as integral and essential to that project. In working with the plan, one is not free to undertake or defer tasks independently of the other tasks comprising the project, nor is there any relative priority to be recognized among such tasks.

2.3.2 Numbering System

As a convenience in working with the plan, a numbering system for the elements in it was developed. To provide ample "number space" for future growth and revisions of the plan, it was decided to adopt a six-digit, coded system. The first two digits denote the number of the project area. Since 14 primary problem areas were identified in the problem dissection process, there are 14 project areas with numbers assigned as indicated in Figure 3. The second pair of digits is the number of the project. The third pair pertains to the task. Thus, the number 030916 designates Task Number 16 in Project Number 9 of the third project area.

In structuring the plan, the numbers were chosen so that project areas surviving from the prior CVS plan kept the same numbers though in different form. Thus, the project area Collisions/Rammings/Groundings formerly had the number 500 and is now 050000. This retention of numbering significance could not, however, be carried out for projects and tasks.

2.3.3 Timing

The plan was developed for the five-year period starting in fiscal year 1979. The content of the plan, therefore, is work to be done in that period assuming that work now planned during the interim period is completed.

3.0 THE RDT&E PROGRAM

3.0 THE RDT&E PROGRAM

The program plan for marine safety and environmental protection consists, at this stage of development, of 14 project areas which are variously subdivided to form projects and tasks. The following table summarizes the plan and its estimated annual budgets as it now stands. The 6-digit numbering plan for all program items has been adopted and applied in such a way that numbering "space" is left for future project work items and tasks.

As discussed earlier in this report, 13 of the project areas in this plan, the 020000 through 140000 series, correspond to the primary problem areas making up the totality of marine domain casualties as analyzed and demonstrated by the logic diagram methodology. The 14th, Project Area 01, Problem Analysis, Definition, and Management, is not aligned with a problem area but, rather, provides all the others with the forecasting and analysis activities required to support their major goals and with information/data on marine safety that are needed in common by all the projects.

The problem area orientation of the program's structure results in a nondisciplinary subdivision of the program's work. This is not considered detrimental in the case of a highly applied type of RDT&E program, as this one is intended to be. However, it does mean that the management of the program must be established on an interdisciplinary basis using task force-type organization to run each of the project area and project work groupings.

The full RDT&E plan is presented in the subsections following the summary Table I. The plan is organized by project areas; the area descriptions are presented in sequence of project area number. Each subsection contains three types of presentations.

- A project area discussion. This is textual matter describing the background problem area addressed, the principal hazards, pertinent technological trends in the project area, and the research strategy adopted for the project area.

- Project description sheets. One is included for each project in the project area. They are in the form of a standardized worksheet which briefly describes the project's goals and procedures and gives a table showing annual funding levels for the work items comprising the project.

TABLE 1. SUMMARY OF PROGRAM PLAN

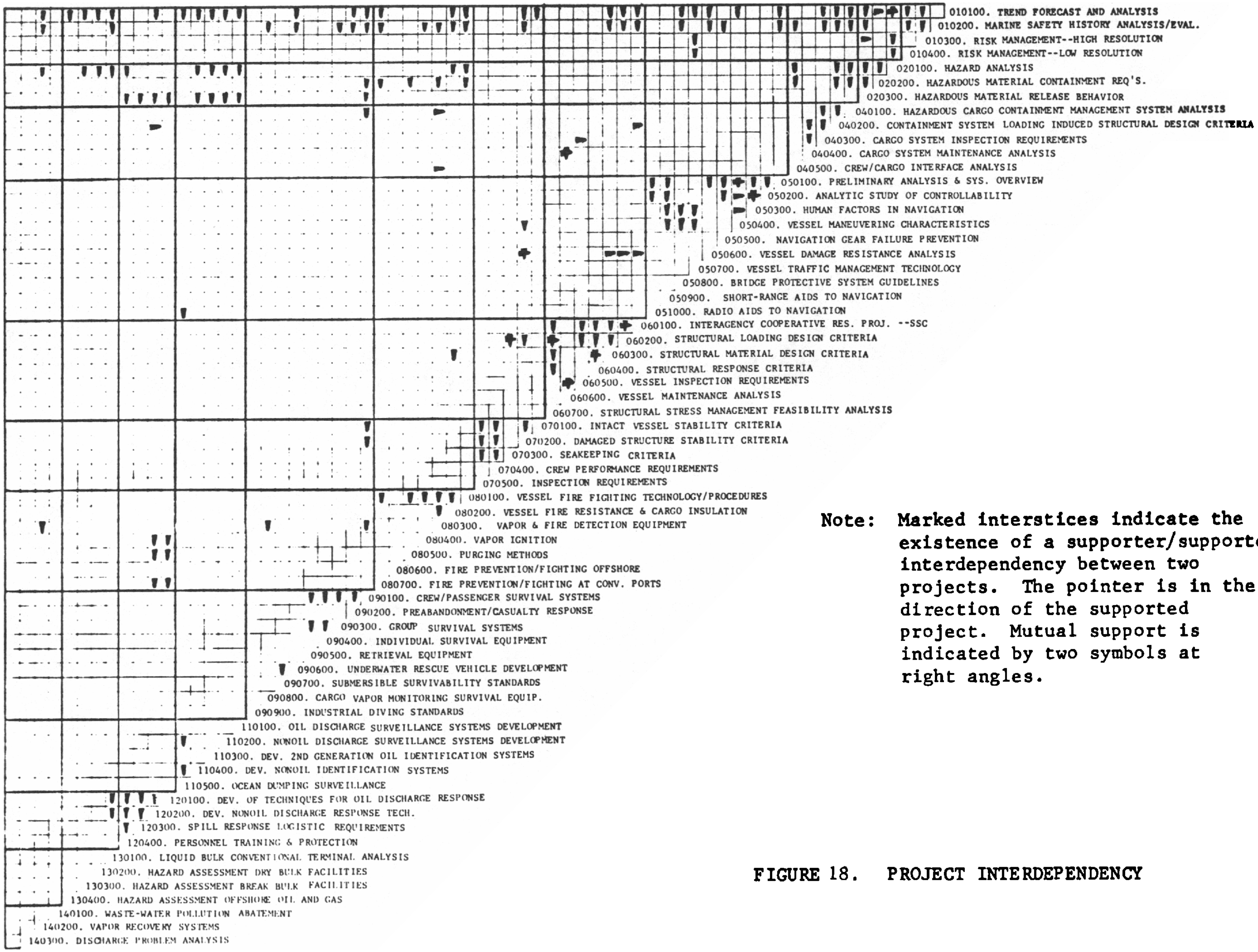
Program Item Number	Project Areas and Projects	Annual Costs - $1000's 1	2	3	4	5	Program Costs, $1000's
010000	PROBLEM DEFINITION	1275	2000	1950	1750	1650	8625
010100	Trend Forecast and Analysis	75	100	100	100	100	475
010200	Marine Safety History Analysis/Eval.	500	400	400	400	300	2000
010300	Risk Management--High Resolution	550	1250	1250	1250	1250	5550
010400	Risk Management--Low Resolution	150	250	200	--	--	600
020000	HAZARDOUS MATERIALS CHARACTERISTICS	1000	1100	1200	1200	1200	5700
020100	Hazard Analysis	300	300	250	300	200	1350
020200	Hazardous Material Containment Req's.	200	200	350	400	500	1650
020300	Hazardous Material Release Behavior	500	600	600	500	500	2700
030000	CARGO LOSS PREVENTION	--	--	--	--	--	--
040000	HAZARDOUS MATERIAL CONTAINMENT SYSTEM SAFETY	650	600	750	775	675	3450
040100	Hazardous Cargo Containment Management System Analysis	400	300	300	300	300	1600
040200	Containment System Loading Induced Structural Design Criteria	200	200	200	100	--	700
040300	Cargo System Inspection Requirements	50	100	100	200	50	500
040400	Cargo System Maintenance Analysis	--	--	100	100	200	400
040500	Crew/Cargo Interface Analysis	--	--	50	75	125	250
050000	COLLISION/RAMMING/GROUND PREVENTION	6905	6810	6820	5930	5305	31770
050100	Preliminary Analysis & Sys. Overview	125	125	125	125	125	625
050200	Analytic Study of Controllability	--	250	250	250	300	1050
050300	Human Factors in Navigation	900	1150	900	700	600	4250
050400	Vessel Maneuvering Characteristics	820	660	400	--	--	1880
050500	Navigation Gear Failure Prevention	200	250	300	100	--	850
050600	Vessel Damage Resistance Analysis	--	--	200	200	300	700
050700	Vessel Traffic Management Technology	1700	1200	1200	1000	750	5850
050800	Bridge Protective System Guidelines	100	150	50	100	100	500
050900	Short-Range Aids to Navigation	1140	965	1285	1125	1210	5725
051000	Radio Aids to Navigation	1920	2060	2110	2330	1920	10340
060000	STRUCTURAL FAILURE	1280	2030	1485	2365	1560	8720
060100	Interagency Cooperative Res. Proj.--SSC	200	205	210	215	210	1040
060200	Structural Loading Design Criteria	450	750	600	1150	600	3550
060300	Structural Material Design Criteria	150	250	50	150	200	800
060400	Structural Response Criteria	130	200	150	200	150	830
060500	Vessel Inspection Requirements	150	275	225	300	180	1100
060600	Vessel Maintenance Analysis	100	100	100	150	100	550
060700	Structural Stress Management Feasibility Analysis	100	250	150	200	150	850
070000	FLOODING, CAPSIZING, FOUNDERING HAZARD CONTAINMENT	1210	1625	1575	1025	550	5985
070100	Intact Vessel Stability Criteria	350	525	550	225	100	1750
070200	Damaged Structure Stability Criteria	330	450	275	200	100	1355
070300	Seakeeping Criteria	405	450	425	350	200	1830
070400	Crew Performance Requirements	50	100	225	225	150	750
070500	Inspection Requirements	75	100	100	25	--	300
080000	FIRE/EXPLOSION HAZARD CONTROL	525	905	1350	1115	700	4745
080100	Vessel Fire Fighting Technology/ Procedures	150	250	375	300	200	1275
080200	Vessel Fire Resistance & Cargo Insulation	100	200	250	100	100	750
080300	Vapor & Fire Detection Equipment	100	175	150	250	75	750
080400	Vapor Ignition	75	180	200	250	175	880
080500	Purging Methods	--	--	125	100	50	275
080600	Fire Prevention/Fighting Offshore	100	100	50	100	100	450
080700	Fire Prevention/Fighting at Conv. Ports	--	--	200	15	50	365

TABLE 1. (Continued)

Program Item Number	Project Areas and Projects	Annual Costs - $1000's 1	2	3	4	5	Program Costs, $1000's
090000	PERSONNEL SAFETY AND SURVIVABILITY	945	1885	2235	1875	790	7730
090100	Crew/Passenger Survival Systems	175	325	250	250	75	1075
090200	Preabandonment/Casualty Response	80	100	120	100	40	440
090300	Group Survival Systems	200	270	300	300	150	1220
090400	Individual Survival Equipment	50	150	300	200	100	800
090500	Retrieval Equipment	125	300	275	75	25	800
090600	Underwater Rescue Vehicle	50	110	200	250	--	610
090700	Submersible Survivability Standards	40	80	140	100	100	460
090800	Cargo Vapor Monitoring Survival Equip.	75	225	350	300	200	1150
090900	Industrial Diving Standards	150	325	300	300	100	1175
100000	NORMAL MARINE OPERATION - INDUCE ENVIRONMENTAL DEGRADATION MINIMIZATION	--	--	--	--	--	--
110000	DISCHARGE DETECTION AND IDENTIFICATION	3140	1600	1860	2150	950	9700
110100	Oil Discharge Surveillance Systems Development	1850	250	100	--	--	2200
110200	Nonoil Discharge Surveillance Systems Development	--	300	700	1300	750	3050
110300	Dev. 2nd Generation Oil Identification Systems	590	405	500	500	100	2095
110400	Dev. Nonoil Identification Systems	650	595	560	350	100	2255
110500	Ocean Dumping Surveillance	50	50	--	--	--	100
120000	DISCHARGE RESPONSE	6825	6900	5500	3575	1325	24125
120100	Dev. of Techniques for Oil Discharge Response	4675	4175	2850	2025	625	14350
120200	Dev. Nonoil Discharge Response Tech.	1600	2100	2000	1000	500	7200
120300	Spill Response Logistic Requirements	100	300	450	350	100	1300
120400	Personnel Training & Protection	450	325	200	200	100	1275
130000	HAZARDOUS MATERIAL TRANSFER SYSTEM FAILURE PREVENTION	190	415	370	210	125	1320
130100	Liquid Bulk Conventional Terminal Analysis	75	150	75	50	50	400
130200	Hazard Assessment Dry Bulk Facilities	25	50	65	110	25	285
130300	Hazard Assessment Break Bulk Facilities	40	75	75	--	--	190
130400	Hazard Assessment Offshore Oil and Gas	--	40	80	50	50	220
140000	NONMARINE CASUALTY-RELATED DISCHARGE PREVENTION	500	1150	1150	900	550	4250
140100	Waste-Water Pollution Abatement	500	1000	1000	700	500	3700
140200	Vapor Recovery Systems	--	150	150	150	--	450
140300	Discharge Problem Analysis	--	--	--	50	50	100
	Program Totals	24,445	27,020	26,245	22,870	15,380	115,960

- Task description sheets. These sheets provide descriptions of each task comprising the project.

In addition to this descriptive matter the project and task sheets include, where applicable, notations of interactions among work items. Such interactions exist where one item has been defined on the assumption that it will receive support from some other item in terms of data, knowledge, methods, or experimental equipment. The interactions are summarized in Figure 18. Th s figure is in the form of a single-entry matrix. Interactions exist where an arrowhead marker has been placed at an interstice. The arrowhead points toward the supported project.



Note: Marked interstices indicate the existence of a supporter/supported interdependency between two projects. The pointer is in the direction of the supported project. Mutual support is indicated by two symbols at right angles.

FIGURE 18. PROJECT INTERDEPENDENCY

3.1 PROBLEM ANALYSIS, DEFINITION, AND MANAGEMENT PROJECT AREA (010000)

3.1 PROBLEM ANALYSIS, DEFINITION, AND MANAGEMENT PROJECT AREA (010000)

This project area includes all the research effort needed to identify and assess current and future hazards to safety and environmental protection in the marine domain. This research performs the dual role of (1) providing direction, motivation, and technical information to all the other project areas in the RDT&E program; and (2) providing a technical information base and communication of evaluated information on safety topics to other parts of the Coast Guard and the maritime technical community in general. As indicated previously, this project area was not identified as an explicit outgrowth of the logic employed to identify and define the other project areas. Rather, it was evident from the onset of the plan design work that the functions of problem analysis, definition, and management would be required as a primary tool of direction and integration for the whole program.

3.1.1 Technological Trends

Risk assessments in transportation are difficult to make at best--the best being where the technology involved is relatively static so that a strong experience factor exists. Under these circumstances, it is still necessary to identify hazards present in the system and estimate, on some rational basis, the relative magnitude of the risks presented by these hazards. These are difficult tasks because of the impossibility of setting high confidence probabilities on sequences of dangerous occurrences. This difficulty is magnified greatly, however, when the system at issue is passing through a period of substantial technological change--as is the case with marine transportation. The change trends are considerable and are fraught with possible new hazards for crew, vessels, the public, the marine industry, and the environment.

Most of these important trends are based on the industry's energetic response to new opportunities presented to it. The number of different, new hazardous types of cargo entering traffic is rising--the increasing offshore industry, the onset of LNG trade and offshore oil and gas activities are merely the most publicized examples in point. Much of this new traffic in hazardous materials (principally chemical intermediates) is flowing in the inland waterway system where the hazard potential to the public-at-risk is far greater than in the case of similar materials in overseas trade. In both arenas, new types of containment system materials and configurations are required; new methods of managing the cargo's state--its temperature, pressure, vapor concentration, and so on--must be developed and implemented; and, in many cases, new forms of vessels, such as container ships or deep sea barges, are being developed and are presenting new problems in engineering design for assurance of satisfactory stability and structural integrity in all kinds of sea states.

At all the nodes in the marine domain--ports, harbors, roadsteads--traffic densities are rising with a concomitant, inherent increase in the risk of collisions. Commercial vessel operations are developing in different areas of the world where new safety problems of large magnitude may develop. This is especially true in the case of liquid bulk cargo vessels operating in the polar regions in large volume traffic--a new aspect of maritime transportation that is virtually certain to be a reality within the planning period of concern to this RDT&E program. Finally, VLCC and ULCC incidence in U.S. waters will become a reality with deepwater port developments. Other deepwater concerns will develop, with ocean industrialization and increasing Coast Guard responsibility in the OCS.

3.1.2 Project Area Research Strategy

Analysis of the functional requirement outlined above resulted in the identification of need for four interrelated research efforts. First is the necessity to establish and maintain a consistent and rational forecast of the future in the marine domain. This forecast comprises the baseline picture of the operations, cargoes, routings, vessel types, and traffic volume to be anticipated and planned for in the future. The anticipation of hazards and assessments of risk to be made can then be based on the framework provided by this forecast. Also, the continuing updating of this forecast provides an excellent basis for measuring progress and effect of the RDT&E program. Thus, this project is also assigned the responsibility of providing annually recommendations for an updated 5-year RDT&E plan.

Second is a project aimed at developing and integrating the various information flows now used by the Coast Guard's Headquarters and field activities into a highly coordinated system--a marine safety information system. This system would be developed to serve with effectiveness all users in the W and M Offices. It would incorporate existing systems such as PSRS into newly developed systems serving such functions as inspection.

Two projects are established to develop methodologies for making assessments of risk levels associated with marine transportation casualties and evaluating alternative methods of managing these risks. The first is a high resolution system based on micro-statistics and employing sophisticated and rigorous analytical models. In concept, such a system will afford the Coast Guard a comprehensive tool for problem quantification, solution indications, and cost-benefit evaluation for all facets of Coast Guard regulatory activities. While this is a worthwhile goal, high technical risks surround this endeavor. Therefore, a second project attacks the problem of risk management on a more aggregated level. This low-resolution system utilizes macro-statistics to develop casualty/economic profiles which form a framework to apply technical judgements in a recordable and consistent manner.

LEVEL: Project **NEXT LEVEL ITEM:** Problem Analysis, Definition, and Management Project Area **ITEM NUMBER:** 010100

TITLE: Trend Forecast and Analysis

TECHNICAL RÉSUMÉ: The objective of this project is to provide Coast Guard personnel with a continuing view of the future marine domain to facilitate the identification of problem areas and possible Coast Guard endeavors. The research approach consists of (1) the development of an overall forecast of pertinent trends, and (2) the analysis of this forecast to identify hazards and problem areas. The principal output of this project is to be an annual report analyzing the hazards and problems and recommending update items for the integrated RDT&E plan.

PROJECT INTERFACES: Supported by 020100 and 020200.

Task Designation	Program Year 1	2	3	4	5	Total Funds
010101 Trend Forecast	50	50	50	50	50	250
010102 Hazard Trend Analysis	25	50	50	50	50	225
Total Funds	75	100	100	100	100	475

LEVEL: Tasks NEXT LEVEL ITEM: Trend Forecast and Analysis Project PROJECT: 010100

010101 Trend Forecast

Provide a continuing--annually updated-- forecast of the marine transportation domain in terms of commercial vessel development, facility siting, cargo shipping patterns, and types of commodities to be carried. The forecasting horizon should be 20 years. Construct the forecast by first identifying an array of specific parameters or descriptors of the marine transportation domain which, taken together, provide a complete description of the three factors noted above. Then identify the driving forces causing or capable of causing change in these parameters/ descriptors utilizing historical examples as a principal tool of identification. Assemble data to define the past and current trends of each parameter/descriptor and then extrapolate these into the future, modifying the extrapolation of judgmental basis in light of the controlling forces of change. Construct a consistent set of scenarios describing maritime industry futures of varying degrees of expected likelihood.

010102 Hazard Trend Analysis

Analyze the trend forecasts developed in 010101, along with on-line results from 010200, 010300, 020100, and 020200, to identify topics where R&D actions may be required or should be revised to help forestall the emergence of new hazards or the exacerbation of current problems. Of particular concern are new materials likely to enter the maritime traffic as hazardous cargoes, or technological changes aimed at developing greater efficiency or less cost in the marine domain. Also of interest is the identification of new opportunities to utilize technological advancements in other fields--such as in computers, reliability science, human engineering, and the like--to facilitate marine technology by upgrading safety. Formulate findings in terms of a systematic problem array and weighting utilizing the types of analysis presented earlier in this report. Solicit and obtain Coast Guard top-management inputs to the final process of problem identification and weighting. Based on the results of this analysis, prepare a recommended revision and update of the Coast Guard's 5-year RDT&E plan reflecting current projection of hazard level assessments and state of knowledge assessments. This reporting process must be appropriately dovetailed in time with annual budgeting processes of Coast Guard Headquarters.

LEVEL: Project NEXT LEVEL ITEM: Problem Definition, Analysis, and Management Project Area ITEM NUMBER:010200

TITLE: Marine Safety History Information System

TECHNICAL RÉSUMÉ: The purpose of the project is to provide a centralized information capability to support the detection of real and emerging safety problems in the marine transportation domain. This will support all Coast Guard missions not only for problem definition but also for performance feedback and monitoring of past Coast Guard actions. The research includes determination of all user needs and the establishment of a coordinated data base and processing capability able to respond to all user needs in a timely fashion.

PROJECT INTERFACES: None supporting.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
010201 Completion of MSIS	400	200	200	150	75	1025
010202 Casualty Investigation and Analysis	25	125	125	175	150	600
010203 Special Casualty Analysis Tasks	75	75	75	75	75	375
Total Funds	500	400	400	400	300	2000

LEVEL: Tasks NEXT LEVEL ITEM: Marine Safety History Information Systems Project PROJECT: 010200

010201 Completion of MSIS

Develop a prototype MSIS and exercise within limited experimental area for testing and evaluation. Refine and revise as necessary to suit all user needs. Develop final system and implement Coast Guard-wide.

010202 Casualty Investigation and Analysis

While reporting/analysis features regarding casualties are incorporated within MSIS, the type and quality of information captured must be defined. Evaluate numerous past casualty reports to determine the type of information currently captured and its problem identification potential. Review past special casualty analysis projects to correlate problems and recommendations. Discuss needs for casualty feedback with concerned Offices and Divisions within the Coast Guard to define needs and expectations. Discuss investigation problems and prospects with field casualty investigators. Based on this, define and recommend improved reporting and analysis procedures and formats. Incorporate these within MSIS for a limited field test. Refine results and implement Coast Guard-wide.

010203 Special Casualty Analysis Tasks

While 010201 and 010202 may obviate this task in future years, special analyses are required in the interim. This is a level funding task with an initial program aimed at providing immediate, urgent answers to various Division needs. This program is an extensive analysis of U.S. and foreign casualty data to determine underlying failure patterns which can serve to identify the interaction among the various elements of the marine transportation system (e.g., pilot, vessel, pathway, aids to navigation, etc.). Output of the program will be a primary input to 010202.

LEVEL: Project NEXT LEVEL ITEM: Problem Analysis, Definition, and Management Project Area ITEM NUMBER: 010300

TITLE: Marine Domain Casualty Risk Management System Development--Micro-Statistical Based

TECHNICAL RÉSUMÉ: The purpose of this project is to develop a systematic, quantitative method for analytically treating the combinational effects of all elements of the marine domain insofar as they interact to produce marine casualties and consequential damage. These models and techniques will explicate, at a detailed level, all factors over which the Coast Guard can exert control and the sensitivity of the expected casualty profile to possible variations in these actions. The specific tasks to be performed are: (1) expand the spill risk model to address noncollision casualties and to further develop ship containment and transfer with models and to standardize cost benefit analysis of safety actions, (2) expand the vulnerability model, and (3) adaptation of the general model to local city, river, and coastal areas and hand off to Coast Guard.

PROJECT INTERFACES: Supported by 010100, 010200, and 020300.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
010301 Risk Assessment Methodology	500	850	750	150	--	2250
010302 Assessment of Damage Potential	50	400	500	500	250	1700
010303 Implement Methodology Within Coast Guard Regulatory Process	--	--	--	600	1000	1600
Total Funds	550	1250	1250	1250	1250	5550

LEVEL: Tasks **NEXT LEVEL ITEM:** Micro-Statistical-Based Risk Analysis Project **PROJECT:** 010300

010301 Risk Assessment Methodology

Using results from 010202 or independent analyses, identify significant parameters controlling the occurrences of rammings, groundings, structural failures, capsizing, flooding, fires and explosions, and their spill consequences. Survey existing risk, damage models. Adopting these or initiating as necessary, develop models and analytical framework for predicting the probability of any marine casualty and the causal chain probabilities associated with these casualties. Develop required experimental procedures to define and quantify critical parameters and verify models.

010302 Assessment of Damage Potential

Using hazard models from Project 020301, expand the capabilities of the Vulnerability Model to cover all hazardous materials. Establish critical model tests to be performed. Close liaison with Project area 020300 is required.

010303 Implement Methodology Within Coast Guard Regulatory Process

Demonstrate methodology in selected city, river, and coastal areas. Document fully the required input requirements, computer resource requirements, and output accuracy limits with associated confidence. Hand-off to Coast Guard with recommendations on future maintenance requirements.

LEVEL: Project NEXT LEVEL ITEM: Problem Analysis, Definition and Management Project Area ITEM NUMBER: 010400

TITLE: Marine Domain Casualty Risk Management System Development--Macro-Statistical Based

TECHNICAL RÉSUMÉ: The purpose of this project is to develop high-level risk management techniques which utilize macro-statistical bases as a uniform framework for applying engineering judgement in assessing risk levels and potential reduction due to alternative Coast Guard actions. A similar high-level marine economic structure is included for cost-benefit assessments and the determination of regulatory inflationary impact. Three tasks are included: (1) macro-economic profile of the marine domain, (2) development of low-resolution risk management techniques, and (3) methodology demonstration.

PROJECT INTERFACES: Supported by 010100 and 010200.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
010401 Macro-Economic Profile of the Marine Domain	150	50	--	--	--	200
010402 Develop Low-Resolution Techniques		200	50	--	--	250
010403 Methodology Demonstration			150	--	--	150
Total Funds	150	250	200	--	--	600

LEVEL: Task **NEXT LEVEL ITEM:** Macro-Statistical-Based Risk Analysis Project **PROJECT:** 010400

010401 Macro-Economic Profile of the Marine Domain

Identify major cost items in marine activities. Determine sensitivity to various vessel type/route/cargoes. Select subsets, consistent with the variation in cost parameters and define costs, taking care to ensure that the basic variables which are influenced by Coast Guard actions are explicity (e.g., manning, capital costs, operating costs, etc.). Develop an economic guideline manual to be used as a framework for consistent economic/inflationary impact assessments by the various Coast Guard Divisions. Include the framework for integrating judgement into the process and include case studies as examples of use.

010402 Develop Low-Resolution Risk Managment Techniques

Using results of Task 010203, develop a macro-statistical probabilities "model" for expected casualty frequency, type, causal factors, etc. Sensitivity should be such that, by incorporating engineering judgements, the impact of alternative Coast Guard action can be assessed; e.g., the potential impact of VTS in a given harbor. At a minimum, such a "model" should provide a reasonable assessment of the real casualty costs which are open for manipulation by Coast Guard actions. Additionally, a framework of judgement application is required to permit uniform/recorded judgements regarding Coast Guard alternative action assessments.

010403 Methodology Demonstration

Using selected case studies, combine the results of 010401 and 010402 into a methodology demonstration. VTS application should be used as one case study.

3.2 HAZARDOUS MATERIAL CHARACTERISTICS PROJECT AREA (020000)

3.2 HAZARDOUS MATERIAL CHARACTERISTICS PROJECT AREA (020000)

This Project Area is intended to incorporate basic research regarding characteristics of hazardous materials as needed to support requirements of virtually all other Project Areas.

3.2.1 Background

Under the broad definition adopted for it in the plan, hazardous materials can be considered the sole independent variable in the complex system comprising the marine domain. It is also assumed to be the "given" variable whose inherent potential hazards to all parties-at-risk must be controlled by adequately manipulating other system variables, be they containment systems, discharge amelioration techniques, or survival systems. Rather than incorporate partial or duplicative hazard assessment studies within each of the affected Project Areas, prudence dictates the centralization of the type of research for coherent, systematic, effective, and efficient results.

3.2.2 Primary Anticipated Hazards

The hazards posed by materials transported, stored, and/or consumed within the marine domain are many and varied. The most obvious hazards are those which are dramatic: the oil slick spreading along the beach or the spectacular explosion and ensuing fire aboard a vessel or in a facility. Perhaps the most feared hazards, however, are the less obvious effects of human exposure to carcinogens or mutagens where the complete assessment of the hazards will not be known for generations to come.

These concerns drive the important consideration of providing adequate containment of hazardous materials throughout their life-cycle in the marine domain -- a life cycle which itself is hazardous. For example, a cargo aboard a vessel is exposed to normal seaway induced acceleration, several transfer operations, a sequence of possible accident situations, as well as a time dependent exposure to its own inherent vices.

A major thrust of this total research plan is to provide basic protection to people, property, and the marine environment by minimizing the hazards posed to hazardous materials through adequate containment system design and reducing the accident potential or profile faced by hazardous materials while in the marine domain. A companion thrust attacks the consequences of hazardous material discharges by upgrading the Coast Guard's ability to detect discharges and reduce their deleterious impact through appropriate response actions. These activities are inherent in every other Program Area of the plan.

It will be noted in these Project Areas that questions of relevant control techniques and appropriate levels of stringency to be applied are ever-present questions -- questions which can only be answered by a thorough understanding of the characteristics properties and hazards of the material being considered. Providing answers to these questions is the basic purpose of the Program Area.

3.2.3 Project Area Research Strategy

The basic research strategy employed in this Project Area is to systematically develop and accumulate information on hazardous material properties and their characteristics with respect to safe containment and discharge response. Three projects are included. The first deals with identifying the basic properties of hazardous materials. The second project translates these characteristics into containment system philosophy and design considerations. This becomes a primary input to Project Area 040000 (Hazardous Material Containment System Failure Prevention). The third project translates these properties into actual discharge situations to provide a basis for developing appropriate action. This provides inputs into Project Area 110000 (Detection and I.D.) and Project Area 120000 (Discharge Response).

LEVEL: Project NEXT LEVEL ITEM: Hazardous Material Characteristics Project Area ITEM NUMBER: 020100

TITLE: HAZARD ANALYSIS

TECHNICAL RÉSUMÉ: The objective of the project is to develop a comprehensive spectrum of hazards associated with hazardous materials and an information system for effective storage and retrieval of material hazards and handling requirements. Four tasks are included thus far" (1) hazard spectrum definition, (2) classification system design, (3) information system design, and (4) testing criteria.

PROJECT INTERFACES: Supported by hazardous cargo traffic projections from 010100 and risk assessment techniques from 010300 and 010400.

Task Designation		Program Year					Total Funds
		1	2	3	4	5	
020101	Hazard Spectrum Definition	75	75	50	75	50	325
020102	Classification System Design	75	75	75	75	50	350
020103	Information System Design	75	75	75	75	50	350
020104	Testing Criteria	75	75	50	75	50	325
Total Funds		300	300	250	300	200	1,350

020101 Hazard Spectrum Definition

Systematically identify the physical characteristics and potential harmful effects of significance which derive from hazardous materials. These should include, but not be limited to physical, chemical, and toxic properties; and carcenogenic, mutagenic, and similar effects; corrosivity and reactivity effects as they influence containment system integrity; and reactivity potential with other materials. Include considerations of the mode in which the hazard is presented (e.g., breathing, contact, obsorption through skin).

020102 Classification of Hazardous Materials

Based on 020101 above, develop a structure for classifying hazardous materials for rapid and meaningful identification of hazard potentials. Identify issues and resolutions associated with trade name variations.

020103 Hazard Information System Design

Re-examine CHRIS in light of 1 & 2 and design as necessary a more complete and responsive information system for storage and recall of the following information as a minimum:

a) Material characteristics
b) Hazard classification/system
c) Cautionary notes
d) Containment and handling requirements
d) Spill characteristics and appropriate mitigation procedures and precautions.

Investigate the utilization of MSIS terminals and communication system for direct and timely field access.

020104 Development of Hazard Testing Criteria

Develop appropriate test information and test procedures required for industry application to adequately define a,b,&c above. Identify the impacts of these tests on the industry.

LEVEL: Project NEXT LEVEL ITEM: Hazardous Material Characteristics Project Area ITEM NUMBER: 020200

TITLE: HAZARDOUS MATERIAL CONTAINMENT REQUIREMENTS

TECHNICAL RÉSUMÉ: The objective of the project is to determine the containment requirements and material treatment requirements for safe transit, storage, and transfer of hazardous material within the marine domain. These tasks are included at present: (1) Alternative containment strategy development, (2) Trade-off analyses, (3) Containment requirement recommendations.

PROJECT INTERFACES: Supported by 020100.

Task Designation		Program Year					Total Funds
		1	2	3	4	5	
020201	Alternative Containment Strategy Development	100	100	100	100	75	475
020202	Trade-Off Analysis	50	50	50	50	25	225
020203	Containment Requirement Recommendations	50	50	200	250	400	950
Total Funds		200	200	350	400	500	1,650

020201 Alternative Containment Strategy Development

Using results of Project 020100 (Hazard Analysis) define requirements for safe containment of hazardous materials over their intended life-cycle in the marine domain. Investigate containment requirement alternatives considering the material in its natural state and in a modified state through techniques such as inerting, inhibiting, refrigerating, and pressurizing, and isolation. Determine the effectiveness of each approach and the critical instrumentation, monitoring, and safety equipment performance requirements.

020202 Trade-Off Analyses

Conduct extensive trade-off studies to identify technical, economic, safety, and implementation interactions.

020203 Develop Recommended Containment Requirements

Based on 01 and 02 above, develop recommendations as to the appropriate level of containment control to be applied. Incorporate results into the information system development effort of Project 020103 (Hazard Assessment).

LEVEL: Project   NEXT LEVEL ITEM: Hazardous Material Characteristics Project Area   ITEM NUMBER: 020300

TITLE: HAZARDOUS MATERIAL RELEASE BEHAVIOR

TECHNICAL RÉSUMÉ: The objective of this project is to determiné the behavior of hazardous materials when released.

PROJECT INTERFACES: Supported by cargo traffic information from 010100, casualty information from 010200, and by material properties information from 020100 and 020200.

Task Designation		Program Year					Total Funds
		1	2	3	4	5	
020301	Release Behavior Model Development	100	100	50	50	50	350
020302	Full Scale Tests	300	400	500	400	400	2,000
020303	Spill Response Factor Analysis	100	100	50	50	50	350
Total Funds		500	600	600	500	500	2,700

020301 Release Behavior Model Development

Using input from Project 020100 (Hazard Assessment) develop categories of hazardous materials based on their expected reactivity (physical and chemical) with water and/or air. Develop hypotheses regarding expected spill behavior. Develop models as necessary to predict release behavior of selected classes of materials. Conduct laboratory and small scale tests to provide preliminary validation of models. Define full scale validation test needs.

020302 Full Scale Tests

In cooperation with industry and other interested government agencies, conduct limited full scale tests as defined above. Analyze results to define model validity and possible laboratory tests to further spill behavior understanding. Finalize release models and incorporate into general vulnerability model.

020303 Spill Response Factor Analysis

In conjunction with the above tests, determine spill characteristics which influence detection requirements and identify the potential for clean up or other mitigating actions (e.g., neutralization).

3.3 CARGO DEGRADATION PREVENTION PROJECT AREA (030000)

3.3 CARGO DEGRADATION PREVENTION PROJECT AREA (030000)

This project addresses the general problem of cargo damage or loss wherein the hazards pertain solely to the cargo, manifesting themselves in physical damage or change of state such as to reduce or destroy its economic usefulness.

3.3.1 Background

The Coast Guard, through various legislative actions, is charged with protecting life, limb, property, and the marine environment from damage incurred within or incidental to activities in the marine domain. Recently, this has been interpreted to include protecting the economic value of cargoes transported in the marine domain. An example of this interpretation is the Coast Guard's role in international cooperative efforts pertaining to container safety and the security of container contents.

3.3.2 Primary Hazards

Cargo degradation can occur, of course, when any cargo containment system is breached or when cargo is lost due to spills during cargo transfer operations. These two kinds of hazards are identified in this program plan as primary problem areas; they are covered in equivalent project area treatments elsewhere in the plan.

The hazards to be dealt with in this project area are those which can result in damage to the cargo without casualties having occurred to the cargo containment system. Two main classes of hazards are defined: those resulting in physical loss of cargo and those which can change its state. Physical loss hazards include theft, shrinkage during transit, and loss overboard (as when deck-loaded containers are swept overboard in heavy seas). Also included in this category are failures of cargo environmental control devices such as heating coils or inerting atmospheres which can result in state changes of cargoes requiring special environments.

3.3.3 Project Area Research Strategy

The hazards of concern here apply with even greater criticality in several other primary problem areas. Maintaining cargo in an intact, inherently safe condition free of contaminants is a prerequisite for controlling hazards posed to personnel, vessels, and the marine environment where the cargo is of such a nature that exposure to it is hazardous for any of these parties-at-risk. Thus, RDT&E projects to support the Coast Guard's various efforts to ensure safe cargo states are naturally and logically generated in several other project areas. Such projects are credited appropriately to the extent that they contribute in this problem area, and their relevance is noted on the project description sheets. For example, Project 040100 "Hazardous Cargo Containment/Management Systems Analysis" is a broad examination of the various means needed for keeping cargoes intact and in a safe state.

This being the case, it was concluded that the most important aspects of this primary problem area are satisfactorily covered elsewhere. Not so covered are considerations of theft and shrinkage. These hazard areas are viewed as being of potential but not immediate importance; hence, no projects addressing them are identified for this plan. The net result of this project area strategy is that no projects are presented here at this time. The project area is included in the plan, as in the case of Project Area 10, "Normal Marine Operation-Induced Environmental Degradation Minimization", to reserve the topic identification so as to facilitate rapid assimilation of future projects into the plan's structure.

3.4 HAZARDOUS MATERIAL CONTAINMENT SYSTEM FAILURE PREVENTION PROJECT AREA (040000)

3.4 HAZARDOUS MATERIAL CONTAINMENT SYSTEM FAILURE PREVENTION PROJECT AREA (040000)

The hazardous material containment system consists of all containment equipment--holds, containers, tanks, manifolds, transfer piping, fittings, etc--plus all the equipment and systems providing and monitoring the environmental conditions for the cargo. Environmental conditions include pressure, temperature, atmosphere, ventilation, and any other special conditions which may be necessary for cargo safety.

3.4.1 Background

One of the major trends generating concern in the problem area addressed here is, of course, the increase in waterborne traffic in hazardous materials requiring special environmental treatment. The most prominent of these are LNG, chlorine, a variety of acids, and several intermediates important in the manufacture of plastics. These have posed the need for the provision of special tank linings, specialized anticorrosive materials, the provision of inert atmospheres, the use of inhibition agents, requirements for new and sophisticated temperature maintenance and pressure control equipment. In the case of LNG, completely new designs for tanks--both in materials and structural design approach--have been required to handle the cryogenic temperatures and boil-off requirements posed by this material. A major expansion in the shipment of cryogenic materials can be foreseen.

Other trends affecting this problem area are: (1) the increase in size of tank vessels with corresponding increase in the size of cargo tanks themselves, (2) the rapidly growing commerce on inland waterways in the shipment of materials deemed hazardous, (3) the development and growing use of container ships transporting liquid bulk products in movable tanks (tank trucks, rail tank cars) adding to the already well-developed use of movable tanks in barges, and (4) an underlying trend throughout maritime technology to design and operate with reduced safety factors as one response to economic pressures toward greater cost effectiveness of waterborne transportation.

While concern about these circumstances is entirely justified, it is preoccupied with the catastrophe--a large spill of extremely toxic and/or explosive material. There are less catastrophic but equally justifiable areas of concern pertaining to this project area: fuel stowage, stowage of ship stores, hazardous materials in packaged form to cite a few.

These concerns extend to containment facilities on offshore platforms and offshore industrial facilities, as well as containment systems located in terminal areas. As a result, this project area is aimed at reducing hazards associated with failures in containment systems in a large variety of applications as they occur in the marine domain.

3.4.2 Primary Anticipated Hazards

The main hazards of concern are two-fold: (1) loss of integrity of the physical containment system due to conditions originating from within that system releasing hazardous material to the environment or setting up conditions for a vessel casualty of the fire/explosion type; or (2) failures that are secondary to a vessel or facility casualty.

3.4.3 Project Area Research Strategy

Problem areas giving rise to these hazards are attacked with five separate projects. Two are concerned with the basic question of adequate containment system design. The first of these is a complex of work items comprising a general, continuing systems analysis of all aspects of hazardous material containment systems and their interaction with different types of materials; the second is concerned with assessment of loading environment in which containment integrity must survive and the resulting design criteria implications. The third and fourth projects are exploratory programs aimed at investigating the relevance of reliability engineering to the specification of performance standards for containment components and the improvement of Coast Guard inspection methods and equipment. Finally, the fifth project examines the personnel capabilities required for safe operation and maintenance of the containment system.

LEVEL: Project NEXT LEVEL ITEM: Hazardous Material Containment System Failure Prevention Project Area ITEM NUMBER: 040100

TITLE: Hazardous Material Containment/Management System Analysis

TECHNICAL RÉSUMÉ: The objective of this project is to provide knowledge and data as necessary to support actions aimed at ensuring that containment system design and associated management functions--including vapor management--are commensurate with hazards posed by materials being contained. Research approach consists of (1) a critical examination of materials to classify them by containment problem categories, (2) analysis of the current state of the art of containment/management system design knowledge re each material class and identification of possible deficiencies in hazard control, (3) analytical and experimental studies to develop improved containment/management capabilities, (4) feasibility studies of these measures, and (5) studies of inspection factors.

PROJECT INTERFACES: Supported by vapor detection information from 080300, cargo traffic information from 010100, casualty information from 010200, and material property information from 020100 and 020200.

Task Designation		Program Year 1	2	3	4	5	Total Funds
040101	Cargo Factor Analysis	200	--	--	200	100	500
040102	Containment/Management	100	150	--	--	100	350
	State of the Art Analysis	100	100	150	--	--	350
040103	Design Criteria Studies	--	50	150	--	--	200
040104	Technical-Economic Studies	--	--	--	100	100	200
Total Funds		400	300	300	300	300	1600

LEVEL: Tasks NEXT LEVEL ITEM: Hazardous Cargo Containment/ Management System Analysis PROJECT: 040100

040101 Cargo Factor Analysis

Using on-line results and inputs from Project 020200, identify the critical state variables of various categories of materials and quantify the acceptable ranges of values for safe and secure containment. Identify the critical control system functions required to provide these requirements, such as artificial control, venting pressure/vacuum relief, and inhibition control. Similarly identify the critical aspects of materials with respect to containment system structural design and packaging requirements. Develop classification system for material types based on these critical containment/management factors and select material types of high priority for further cargo system analysis.

040102 Containment/Management State-of-the-Art Analysis

Survey current and proposed contain/management systems designs and practices. Using on-line results and inputs from projects 010100, 020100, 020200, and 010200, perform a detailed parametric analysis of these systems for each priority material type to identify critical relationships among specific characteristics and estimates of containment system design adequacy for present and forecasted situations. Develop measures of performance effectiveness from both the management and structural adequacy standpoints of containment systems. Utilizing these measures and data previously developed, make an analysis of the adequacy of present approaches to containment system design and management functions. Identify deficiencies and develop alternative approaches to rectify them.

040103 Design Criteria Studies

Analyze current containment system design criteria in view of the relationships established in the previous project and measure structural effectiveness for various types of cargoes and variations expected over the life cycle (e.g., corrosion effects). This analysis should include fixed tanks, movable tanks such as rail tank cars, tank trucks, and bulk liquid containers, and hazardous material packages. Reevaluate design criteria in the light of these findings and develop techniques for their application.

040104 Technical-Economic Studies

With respect to identified areas of improvement, perform analytical and experimental studies to verify and develop equipment and structural design improvements. Develop and describe technical/economic nature of each alternative and perform studies to identify trade-off options among technologies, costs, and effectiveness levels.

LEVEL: Project

NEXT LEVEL ITEM: Hazardous Material Containment System Failure Prevention Project Area

ITEM NUMBER: 040200

TITLE: Containment System Loading Induced Structural Design Criteria

TECHNICAL RÉSUMÉ: The objective of this project is to develop an engineering understanding of actual loadings imposed on the structure of cargo containment systems to upgrade the quality of the design process. The research approach consists of (1) a parametric analysis of design criteria, (2) a collection of loading data from laboratory and field test programs, and (3) an analysis of all data available to define the loading parameters associated with different cargo types.

PROJECT INTERFACES: Supported by vessel structural characteristics and behavior information from 060100, by cargo information from 010200, and material properties from 020100, 020200, and 040100.

Task Designation	Program Year 1	2	3	4	5	Total Funds
040201 Parametric Analysis of Design Criteria	200	--	--	--	--	200
040202 Loading Data Gathering	--	200	200	--	--	400
040203 Loading Parameter Definition	--	--	--	100	--	100
Total Funds	200	200	200	100	--	700

LEVEL: Tasks NEXT LEVEL ITEM: Liquid Bulk Cargo Tank Structural Loading PROJECT: 040200

040201 Parametric Analysis of Design Criteria

Identify the dynamic loading design criteria for independent containment designs and correlate with various designs for ships and barges. Include the identification and implications of included design safety factors. Identify and categorize different cargo and containment system characteristics that influence loading. Develop and maintain a priority list of cargoes requiring attention in this project (major inputs from 020100, 020200, and 040101.

040202 Loading Data Gathering

Perform instrumented testing of containment systems in actual operations, expanding the current LNG ship experiments to other general designs, including RO-RO equipment and other movable containers. Perform this work for all cargo types of concern in accordance with priority listings.

040203 Loading Parameter Definition

Analyze data to identify key parameters influencing inertial loading, such as size, cargo characteristics, surface characteristics, vessel motions, and vessel loading characteristics. Determine the adequacy of the design assumptions in relation to structural integrity and hold-down requirements. Recommend improved loading design criteria to eliminate identified deficiencies. Promulgate technical results to maritime technical community through suitable publications. Merge this information with the material induced design criteria efforts of 040100 to develop improved overall containment system design criteria.

LEVEL: Project NEXT LEVEL ITEM: Hazardous Material Containment System Failure Prevention Project Area , ITEM NUMBER: 040300

TITLE: Cargo System Inspection Requirements

TECHNICAL RÉSUMÉ: The objective of this project is to develop pertinent data and information on techniques, equipment, and personnel capabilities for improved cargo system inspections to eliminate degradation failures in service. The research approach consists of (1) a survey of present practice to define problems and identify opportunities to effect improvements, (2) technical analysis of improvement options deemed worthy of further efforts, and (3) feasibility studies as appropriate.

PROJECT INTERFACES: Supported by 040100, 040200, 010100, and 010200. To be coordinated with 060500.

Task Designation		Program Year 1	2	3	4	5	Total Funds
040301	Survey of Current Practices and Improvement Options	50	--	--	--	--	50
040302	Technical Assessment of Options	--	100	100	--	--	200
040303	Technical and Economic Impact Studies	--	--	--	200	50	250
Total Funds		50	100	100	200	50	500

LEVEL: Tasks NEXT LEVEL ITEM: Cargo System Inspection Requirements PROJECT: 040300

040301 Survey of Current Practices and Improvement Options

Survey current inspection techniques, intervals, inspection points, and inspector qualifications as related to the cargo system. Using on-line results and inputs from Projects 010100, 010200, 040100, and 040200, identify critical inspection points and techniques and evaluate the effectiveness of current procedures in identifying key indicators of incipient failures. Establish measures of inspection effectiveness as a basis for further analysis and future performance monitoring. Analyze existing or anticipated deficiencies and identify opportunities to eliminate them through changes in inspection intervals, inspection procedures, and techniques and/or inspector qualifications.

040302 Technical Assessments of Options

Perform necessary development and testing to provide definition to each opportunity in terms of its technical/economic nature and its contribution to the improvement of the inspection process.

040303 Technical and Economic Impact Studies

Identify and analyze the impact of each option on the overall inspection requirements, interfacing with other vessel inspection requirements, as well as its effect on vessel utility. Perform trade-off studies to identify the sensitivity of inspection effectiveness to variations in inspection techniques or intervals. Define the issues to be faced in implementing each of these inspection strategies.

LEVEL: Project   NEXT LEVEL ITEM: Hazardous Material Containment System Failure Prevention Project Area   ITEM NUMBER: 040400

TITLE: Cargo System Maintenance Analysis

TECHNICAL RÉSUMÉ: The objective of this project is to identify deficiencies in maintenance practices which can increase risk of cargo system mishaps and to develop knowledge basic to eliminating those practices through improved maintenance standards and past maintenance inspection. Research approach consists of (1) an assessment of current maintenance practices in the light of failure data to determine deficiencies, (2) conception and evaluation of options in maintenance procedures designed to overcome deficiencies, and (3) compliance factor studies.

PROJECT INTERFACES: Supported by 010200, 040200, and 040300.

Task Designation		Program Year					Total Funds
		1	2	3	4	5	
040401	Assessment of Current Practice	--	--	100	--	--	100
040402	Assessment of Maintenance Procedure Options	--	--	--	100	100	200
040403	Inspection and Compliance Factor Study	--	--	--	--	100	100
Total Funds		--	--	100	100	200	400

LEVEL: Tasks NEXT LEVEL ITEM: Cargo System Maintenance Analysis PROJECT: 040400

040401 Assessment of Current Practice

Survey current maintenance practices--preventive and restorative, running the spectrum from daily crew maintenance operations to and including major yard overhauls. Using on-line results of Project 010200, identify failure modes attributable to inadequate maintenace. Using on-line results of Projects 040200 and 040300, evaluate the influence of maintenace practices on the cargo system integrity and reliability. Establish measures of effectiveness for cargo system maintenance operations and apply these to identify maintenance deficiencies.

040402 Assessment of Maintenance Procedure Options

Formulate the necessary alterations to current practices to ensure adequate life-cycle performance of the cargo system. Assess these options as to technical feasibility and economic impact.

040403 Inspection and Compliance Factor Study

Develop necessary procedures of maintenance monitoring and/or post maintenance inspection/testing to ensure compliance with the above requirements. Establish personnel capability requirement, and means of assuring them through tests or inspection. Since most of the output of this project is likely to be in the form of spot guidance for inspectors, develop a system of technical bulletins and inspection pointers regarding maintenance functions for distribution as a part of Project 010200.

LEVEL: Project NEXT LEVEL ITEM: Cargo System Safety Project Area ITEM NUMBER: 040500

TITLE: Crew/Cargo Interface Analysis

TECHNICAL RÉSUMÉ: The objective of this project is to develop data and information necessary to the establishment of crew performance requirements and operational procedures that are commensurate with hazards of specific types of cargoes. The research approach consists of (1) analysis of hazards related to crew capability deficiencies in handling various types of cargoes, (2) feasibility studies of measures aimed at rectifying identified hazards, and (3) study of pertinent testing factors.

PROJECT INTERFACES: Supported by information on vapor detection and management from 080300, material properties from 020100 and 020200, and casualties from 010200. To be coordinated with 120400 and 070400.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
040501 Crew Capability/Deficiency Hazard Analysis	--	--	50	--	--	50
040502 Technical Economic Impact Studies	--	--	--	75	75	150
040503 Testing Factors	--	--	--	--	50	50
Total Funds	--	--	50	75	125	250

LEVEL: Tasks NEXT LEVEL ITEM: Crew/Cargo Interface Analysis PROJECT: 040500

040501 Crew Capability/Deficiency Hazard Analysis

Analyze all possible phases of interaction between crew members and the cargo system--considering both operational and incidental interactions. Identify the current procedures to be observed at these interfaces. Using on-line results and inputs from Projects 010100, 020100, 020200, and 010200, evaluate the adequacy of these procedures in view of past casualty performance, existing trends, the hazards of specific or classes of cargoes, and the criticality of the task being performed. Perform detailed analysis in a areas where deficiencies are identified. Analyze current procedures in terms of their ability to promote safe and unique actions on the part of the crew member. Identify opportunities for improvement by more precise and rigorous procedures, more stringent crew qualifications, and/or the addition of devices permitting certain actions only if these actions are safe.

040502 Technical-Economic Impact Studies

Develop these opportunities to define their characteristics in terms of technical and economic factors. Perform trade-off analyses to identify options with effectiveness in reducing the incidence of human error.

040503 Testing Factors

Identify implementation techniques and in-service performance monitoring requirements for each identified opportunity. For training improvements, develop qualification standards and training requirements.

3.5 COLLISION, RAMMING, AND GROUNDING PREVENTION PROJECT AREA (050000)

3.5 COLLISION, RAMMING, AND GROUNDING PREVENTION PROJECT AREA (05000C)

The Collision, Ramming, and Grounding (CRG) Problem Area encompasses the class of incidents involving an unwanted transfer of energy resulting from contact of a vessel with another vessel, with the ground, or with fixed structures, such as piers, bridges, or offshore platforms.

3.5.1 Background

CRG incidents have resulted in deaths, injuries, property losses, and degradation of both the marine environment and the performance of the marine transportation system. Minimizing the occurrence and effects of CRG incidents has been an area of continuing research activity for the Coast Guard. However, several interrelated trends have been identified which clearly focus the need for increased RDT&E activity with respect to CRG incidents.

A general increase in shipping activity and an increase in non-commercial use of various waterways results in an increase in the number of potential conflict situations. Increases in vessel size with attendant increases in impact energy increase the loss potential associated with CRG incidents. The adverse effects are amplified by the increase in shipment of bulk hazardous cargoes. The potential deleterious effects of the use of existing ports and waterways by larger vessels are magnified by the increasing concentration of people and property in port areas. Serious potential incidents are associated with the development of offshore deepwater ports. Technological advances in vessel controllability are meeting serious constraints with the laws of physics, and may represent a minor portion of the amount of reduction in potential incidents which is achievable. Increasing regulatory action will be mandated and will meet with considerable resistance by the maritime industry. Regulatory action may actually increase risk if it is not based on a clear understanding of the operator/vessel/waterway interaction and limits of performance capability.

3.5.2 Primary Anticipated Hazards

It is extremely difficult to predict the occurrence or impact of a CRG incident. Historically, ports and waterways have been developed with sufficient tolerance for variations in normal operations. Variations in human control performance, as contrasted with mistakes or blunders, are a normal part of any operation, but the increasing size, complexity, and hazard potential of current maritime traffic indicate that the acceptable error tolerance is rapidly decreasing. It is not yet possible to measure the risk associated with a particular scenario, but the potential hazards associated with a massive oil spill from a VLCC, being almost incomprehensible in its effects, support a need for renewed and increased RDT&E efforts with regard to CRG incidents.

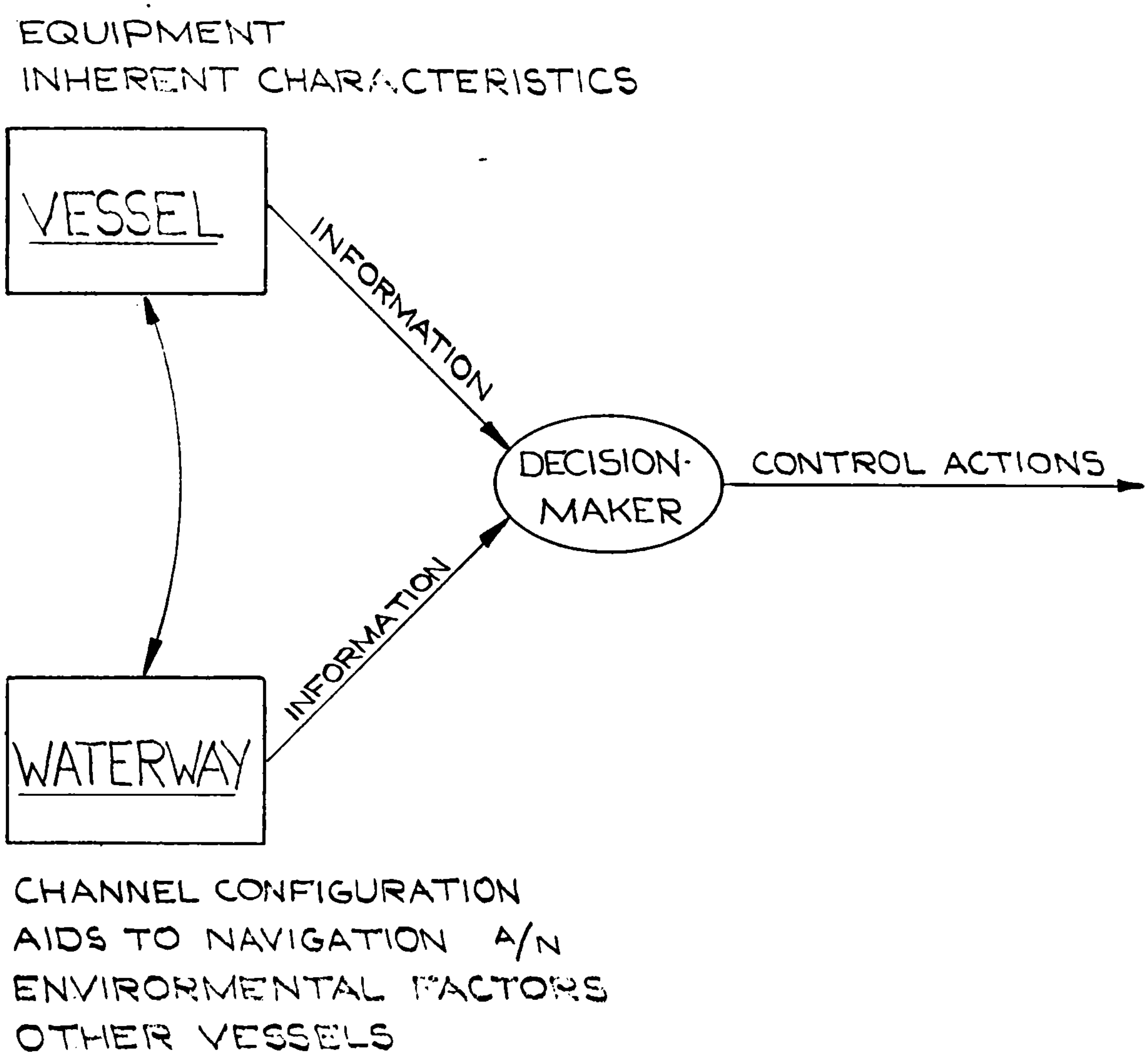
A CRG incident may affect all parties-at-risk, as shown in Figure 7. Additionally, a CRG incident may adversely affect the operation of various components in the marine domain causing an economic loss which is facilitation-oriented and not safety-oriented. The major hazards resulting from a CRG incident are (1) a major fire, explosion, or release of a hazardous material with its attendant potential for harm to people and property in the affected zone, as well as a resulting damage to the marine environment; (2) physical damage to vessel and the impacted vessel or facility which hazards personnel as well as the physical loss involved; and (3) obstructions to any movement of vessels in a particular area. All other hazards are subsets of these, ranging downward in seriousness depending on the size of the fire or explosion, amount and properties of the cargo released, degree of damage to vessels and injury to crewmen, and the duration of closure or restriction of waterborne movement and numbers of vessels so affected.

3.5.3 Project Area Research Strategy

The logic diagram for the CRG incident is shown in Figure 7. As indicated in the diagram, several factors are thought to be influential in causing a CRG incident via the "Imbalance Among Vessel Navigation Capabilities" mode. It must be emphasized that the indicated factors are potential candidates for CRG causal factors. Because of their broad interpretation, it is difficult to conceive of additional factors which could not be subsumed in one of those listed. However, the problem is not one of listing causal factors but rather associating them in a meaningful way. The fact of the matter is we do not know how these factors relate to influencing a CRG occurrence. It is necessary to develop an in-depth understanding of how the human controller, information system, vessel, and pathway interact in normal and abnormal navigation situations. Until this understanding is developed, the CRG problem cannot be adequately defined or resolved.

The research strategy used to identify projects within this area is based on a simple model of a "navigation subsystem", which is identified as a component of various other systems in the marine transportation domain. Since the word "navigation", as used here, means to direct the movement of the vessel safely, a CRG incident occurrence is a failure in the normal operation of the navigation subsystem and the fault-tree analysis can be used to identify component failures.

There are three basic elements in the navigation subsystem: the vessel, the waterway, and the conning officer (otherwise known as the human decision maker and here referred to as the human controller). The vessel element includes the inherent vessel operating characteristics (which are dependent on the operating environment) and specific vessel equipment, such as propulsion and steering equipment or navigation equipment. The waterway element includes factors, such as the channel configuration, physical aids to navigation, environmental factors, waterway use including other vessels, and nonphysical aids to navigation (Vessel Traffic Services). The human controller element includes the person, his information processing capabilities, his stress resistance, and his accumulated knowledge about the waterway and vessel. This model is depicted graphically in Figure 19.



ELEMENTS OF NAVIGATION SUBSYSTEM:

- VESSEL
- WATERWAY
- DECISIONMAKER

FIGURE 19. NAVIGATION SUBSYSTEM MODEL

To structure the research effort it is necessary to examine the navigation subsystem model further. There is an interaction between the vessel and the waterway based on physical characteristics. Certain of these physical characteristics can be examined in isolation and sources of failures identified. The vessel and waterway (and effects of their interaction) provide information to the decision maker who evaluates the information and makes control action to direct the movement of the vessel. Thus, one must consider the physical interaction of the elements, as well as the information flow structure. In addition, for research purposes, certain components of the waterway, namely, aids to navigation and vessel traffic services, are also identified as "services", and it is in this context that the research projects examine those possible failures. The general character of this three-dimensional view provides a basis for categorization of the research projects.

Within this framework, the research requirements logically fall into three general categories.

In the first category, three projects are included: The first is a general system definition project to define the parameters of navigation which attend a CRG incident. The second operates with the "fixed" (e.g., nonhuman control factors) to define expected "perfect controller" navigation performance. The last extends this through an empirical program to assess the human controller characteristics and navigation system impact.

The second category contains two projects. One deals with vessel maneuvering characteristics. The other examines the reliability aspect of navigation and maneuvering systems from the standpoint of CRG prevention.

The third category contains research to investigate performance requirements and improvement options for vessel traffic management systems, short-range aids to navigation, and radio aids to navigation.

In addition to these, two projects are added to investigate CRG mitigation potential. The first deals with vessel damage resistance and the second deals with the design of protective systems for bridges across waterways.

LEVEL: Project NEXT LEVEL ITEM: Collision, Ramming, and Grounding Project Area ITEM NUMBER: 050100

TITLE: Preliminary Analysis and System Overview

TECHNICAL RÉSUMÉ: This project provides a definition of the process of navigation, or the "navigation system", as a basis for identification of and research into the parameters which affect the process. This "system definition" is to be developed prior to "Year 1" of the plan itself, and updated as indicated by the results of further research so the funding shown in the table below, for this part of the project effort, covers only the updating work. The project includes, also, a continuing review of navigation incidents (casualties) and navigational practice to provide guidance to the design and conduct of experiments which are included in other projects.

PROJECT INTERFACES: Supported by information on hazard trends from 010100, by casualty information from 010200, and by vessel information from 050400.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
050101 System Definition Study	25	25	25	25	25	250
050102 Analysis of Navigation Practice	100	100	100	100	100	500
Total Funds	125	125	125	125	125	750

LEVEL: Tasks NEXT LEVEL ITEM: Preliminary Analysis and System Overview Project PROJECT: 050100

050101. System Definition Study

Systematically outline the process of navigation and identify the parameters which influence the practice of navigation. Use as a basis for model development in Project 050200, and experimental dcsign in Project 050300. Review the system definition continually in the light of current information and amend it if indicated.

050102. Analysis of Navigation Practices

Make a continuing analysis of the practice of navigation, encompassing a broad range of examples. Source data would include, among others, reports of casualty investigations and other pertinent literature, interviews with pilots and other experienced navigators, and direct observation of practicing navigators. Use results as inputs to Projects 050200 and 050300, to assure that research and analysis addresses representative samples of all important parameters and situations.

LEVEL: Project NEXT LEVEL ITEM: Collision, Ramming, and Grounding Project Area ITEM NUMBER: 050200

TITLE: Analytic Study of Controllability

TECHNICAL RÉSUMÉ: The purpose of this project is to develop an analytical representation of the navigation subsystem and how the various components interact. When no errors are present, an ideal system is represented and forms a base for comparison when various errors are introduced. Four tasks are included at this time: (1) develop a basic analytic model of the navigation process; (2) conduct an analysis of expected ideal performance; (3) conduct an analysis of automated navigation allowing for certain nonhuman random errors; and (4) conduct an analysis of the effect of human errors.

PROJECT INTERFACES: Supported critically by 050100 and 050300. Supported by 050400.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
050201 Basic Analytical Model of the Navigation Process		250				250
050202 Analysis of Expected Ideal Performance			250			250
050203 Analysis of Automatic Navigation				250		250
050204 Analysis of Effects of Human Error					300	300
Total Funds	--	250	250	250	300	1050

LEVEL: Tasks NEXT LEVEL ITEM: Analytic Study of Controllability Project PROJECT: 050200

050201. Basic Analytic Model of the Navigation Process

Develop an analytic model of the navigation process incorporating parameters describing the channel (waterway), the vessel characteristics, environment, position information, directional guidance information, and other traffic using the waterway. The model will be based on the relationships among these parameters, as well as any other parameters identified in Project 050100, or which may have been overlooked.

050202. Analysis of Expected Ideal Performance

Using the model of 050201, fix the channel, vessel, and environment parameters. Assume that perfect information is available, specifically that position, navigational guidance, set and drift, wind, and other traffic location/characteristics are known with no time delays. Under these conditions, exercise the model to define the ultimate limits on the ability of the vessel to transit the waterway under varying traffic conditions.

050203. Analysis of Automatic Navigation

The objective of this task is to provide an assessment of the performance limitations on automatic navigation (free of human error) and an identification of the performance requirements of an automatic navigation system. This task follows 050202 allowing for introduction of errors and time delays other than those attributable to a human decision maker. Specifically, the model is to be expanded to allow for statistical errors in the information received, inclusion of realistic time delays in the transmission and receipt of information, and time delays and errors in the translation of information into ship control orders. As a subtask, assess, using limited testing if necessary, the performance capabilities of various shipboard sensors, processors, and control mechanisms to provide realistic input data for the model. Using the expanded model and the various errors and time delays, assess the limits of and capability to provide automatic navigation.

050204. Analysis of Effects of Human Error

This task uses the model developed in 050203 to evaluate real-world conditions with the "man-in-the-loop", the human controller. Three subtasks are identified.
(1) The human controller is provided with direct information from on-board sensors and external sources (e.g., position/directional guidance from automated shipboard navigation, traffic location and movement from radar and radio). Using the model, the desired output is a set of definitions of performance requirements of navigation, control and collision avoidance equipment.
(2) Using the results of Project 050300, hypothesize alternative local systems of visual and radar navigation. Using the alternative systems,

exercise the model to evaluate the ability to analytically model the process of visual navigation, using visual and radar fixes, as well as "eyeball" piloting. This will test the ability to use the results of 050301 in place of position and guidance information derived from on-board sensors in (1) above, and attempt to duplicate the results observed in 050302. At the same time, the results of 050302 will be used directly to model such factors as judgment of set and drift, anticipation and execution of turns and other maneuvers. A desired output is a model which can be used to evaluate requirements for visual aide to navigation, or conversely, to define the safe limits for navigation with a given system of aids.

(3) Using the results of (1) and (2) above, test the ability to model navigation using both on-board sensors and data processors, and direct observation of visual aids, other landmarks, other traffic, etc. The desired output is a model which will evaluate requirements of a combined system to ensure safe navigation, or to define the limits of safe navigation of a given combined system.

LEVEL: Project NEXT LEVEL ITEM: Collision, Ramming, and Grounding Project Area ITEM NUMBER: 050300

TITLE: Human Factors in Navigation

TECHNICAL RÉSUMÉ: This project is an in-depth examination of the ability of the human controller to obtain and interpret navigation information, and to use that information in the process of navigation of the vessel. This provides a measure of the human error as input to 050200. Four tasks are identified: (1) static evaluation of aids to navigation; (2) dynamic evaluation of visual aids to navigation; (3) dynamic evaluation of on-board navigation and guidance systems; and (4) dynamic evaluation of combined navigation systems.

PROJECT INTERFACES: Supported by 050100, information on navigation practices, 050200, information on modeling, and 050400, information on vessels.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
050301 Static Evaluation of Aids to Navigation	200	200	200			600
050302 Dynamic Evaluation of Visual Aids to Navigation	500	750	500	400	300	2450
050303 Dynamic Evaluation of On-Board Navigation and Guidance Systems	200	200	200			600
050304 Dynamic Evaluation of Combined Navigation Systems				300	300	600
Total Funds	900	1150	900	700	600	4250

LEVEL: Tasks NEXT LEVEL ITEM: Human Factors in Navigation Project PROJECT: 050300

050301. Static Evaluation of Aids to Navigation

The objective of this task is to develop information about the human ability to estimate or measure position and direction, and to identify the sources and magnitudes of errors, using static methods. Two subtasks are described. (1) Use static tests to determine the ability of a human controller to judge position and direction by direct observation of visual aids to navigation. These methods may include real-world experiments or simulation (beware of model tests which may be invalidated by an exaggeration of binocular vision). Results should be obtained for various types and configurations of visual aids to navigation.
(2) Obtain statistically significant measures of the accuracy with which the human navigator can acquire lines of position and plot fixes using compass bearings on visual aids to navigation, radar ranges and bearings on aids to navigation and other landmarks, and radio direction finders. Results must represent data derived from a broad range of test subjects and types of instruments and equipment in common usage. The results should be categorized, as appropriate, to indicate significant differences in the performance of the human navigators of various classes of vessels (e.g., large commercial ships, small commercial ships, large recreational boats, etc.).

050302. Dynamic Evaluation of Visual Aids to Navigation

The objective of this task is to evaluate the effectiveness of alternative configurations of visual aids to navigation in the actual practice of visual piloting. The task consists of extensive series of trials in both real-world situations and visual simulators. The simulators will permit separation and control of variables while the real-world trials will validate the simulation and expand the knowledge data base. The trials should be progressive in complexity, beginning with simple "channel elements", followed with compound channel elements and selected difficult and/or hazardous situations revealed by the results of 050102. The important variables include: physical characteristics of the ship and the waterway; configuration of the aids to navigation; environmental forces; visibility; number and qualifications of the individual test subjects; traffic in the waterway; quantity, quality, and form of supplementary information; and the effect of casualties in control and information systems. These results are significant input for 050203 and 050204.

050303. Dynamic Evaluation of On-Board Navigation and Guidance Systems

This task is similar to 050302, but here, all position and guidance information is derived from on-board sensors, data processors, and display units. Using results obtained in Project 051000, the position and guidance information, and the methods for its display, will represent realistically the use of Loran-C for precision navigation. The dynamic tests shall include also, however, an investigation of the ability of the human to navigate with continuous, instantaneous, error-free position and guidance information, and to evaluate the limitations on human performance other than those imposed by errors in the navigation system.

050304. Dynamic Evaluation of Combined Navigation Systems

The objective of this task is to evaluate human performance with a navigation system combining visual aids and on-board sensors by using dynamic test methods. The task is a combination of 050302 and 050303. Specifically, the tests shall evaluate the effectiveness of visual aids and on-board electronic navigation systems as supplementary sources of position and guidance information, under varying environmental conditions including clear weather and reduced visibility.

LEVEL: Project NEXT LEVEL ITEM: Collision, Ramming, and Grounding Project Area ITEM NUMBER: 050400

TITLE: Vessel Maneuvering Characteristics

TECHNICAL RÉSUMÉ: The objective of this project is to develop knowledge and technique for predicting and evaluating vessel maneuverability factors. The results of exercising this tool are to provide inputs to Projects 050100, 050200, and 050300. Research approach consists of: (1) a parametric analysis of vessel maneuvering characteristics to structure the problem involved and develop measures of vessel response capability, (2) parametric variation studies to correlate effects of changes in performance variables, and (3) conduct trade-off studies to determine items with the greatest sensitivity of vessel control response.

PROJECT INTERFACES: Supported by hazard trend information from 010100 and by information on navigation practice from 050100.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
050401 Maneuvering Parameters Definition	200					200
050402 Parametric Variation Studies	400	400				800
050403 Trade-Off Studies		200	200			400
050404 Underkeel Clearance	220	60	200			480
Total Funds	820	660	400			1880

LEVEL: Tasks NEXT LEVEL ITEM: Vessel Maneuvering Characteristics PROJECT: 050400

050401. Maneuvering Parameters Definition

Generalizing on the efforts initiated in Project 050100, identify key measures of vessel maneuvering characteristics which influence the vessel's capability to avert a conflict situation (e.g., crash stopping ability, minimum turn radius, etc.). Estimate the probability of occurrence and time duration of loss of maneuverability of all kinds of vessels. Identify the key variables of vessel design and maneuvering gear which define these characteristics. Develop a parametric description of vessel control response capability based on these variables.

050402. Parametric Variation Studies

Perform necessary vessel performance analysis and testing to quantify the effects of these variables. Develop performance profiles for various combination values for these variables as they exist in current vessels in both deep and shallow water maneuvering. Using on-line results and inputs from Project 010100, forecast expected changes in these variables and assess their implications in terms of vessel control response (e.g., assess the implications of larger hull forms, deeper drafts, and lower power-to-weight ratios). Analyze and evaluate performance and effects of maneuvering aids such as drag flaps, bow thrusters, and dual rudders.

050403. Trade-Off Studies

Develop a mathematical model of vessel maneuvering characteristics for use in conjunction with the model analysis work in 050200 and 050300. Using the model, perform trade-off analyses to identify sensitivity of vessel control response to variations in types of maneuvering gear provided for various classes of vessels.

050404. Underkeel Clearance

Based on studies and insight gained in Project 051100, as appropriate, identify the key vessel and operational parameters which influence under-bottom clearance and, through statistical and other methods of analysis, develop a methodology for establishing minimum clearances required in ports and their approaches.

LEVEL: Project NEXT LEVEL ITEM: Collision, Ramming, and Grounding Project Area ITEM NUMBER: 050500

TITLE: Navigation/Maneuvering Gear System Failure Prevention Analysis

TECHNICAL RÉSUMÉ: The objective of this project is to investigate the safety implications of navigation/maneuvering system reliability and maintainability and identify inspection methodologies to assure adequate life-cycle performance of safety-critical elements.

PROJECT INTERFACES: Supported by casualty information from 010200. To be coordinated with 050100 and 050200.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
050501 Failure Mode Analysis	200	100				300
050502 Technical Analysis of Options		100	100			200
050503 Trade-Off Studies		50	100			150
050504 Implementation Analysis			100	100		200
Total Funds	200	250	300	100	-	850

LEVEL: Tasks NEXT LEVEL ITEM: Navigation/Maneuvering System Failure Prevention Analysis PROJECT: 050500

050501. Failure Mode Effects and Criticality Analysis

Using on-line results and inputs from Project 010200, identify critical failure aspects of navigation/maneuvering system components utilizing FMECA techniques. Interfacing with Projects 050100 and 050200, identify those failures which affect vessel control capability in a significant way. For these failures, perform detailed analyses to identify causes of failure and identify alternative approaches to minimize their occurrence through design alterations, maintenance procedures, and/or performance monitoring procedures.

050502. Technical Analysis of Options

Develop these alternatives as necessary to describe the technical/economic nature of each alternative, as well as a measure of effectiveness in reducing failure occurrence.

050503. Trade-Off Studies

Perform trade-off analyses to identify the sensitivity of effectiveness to variations in approach and application rigor.

050504. Implementation Analysis

For each alternative, identify the required actions to ensure adequate life-cycle performance. Identify critical inspection requirements and intervals and identify the resultant implications on other inspection requirements and schedules.

LEVEL: Project NEXT LEVEL ITEM: Collision, Ramming, and Grounding Project Area ITEM NUMBER: 050600

TITLE: Vessel Damage Resistance Analysis

TECHNICAL RÉSUMÉ: The objective of this project is to develop a methodology for evaluating the impact resistance of vessels in collision, ramming, and grounding situations.

PROJECT INTERFACES: Supported by casualty information from 010100 and 010200, by navigation practices and casualty analysis from 050100, by damage protection and collision damage resistance information from 060100, 060200, and 060300. Coordination with 070200 is required.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
050601 Casualty Analysis			200	100		300
050602 Analytic/Experimental Evaluation				100	200	300
050603 Assessment Methodology Development					100	100
Total Funds			200	200	300	700

LEVEL: Tasks   NEXT LEVEL ITEM: Vessel Damage Resistance Analysis   PROJECT: 050600

050601. <u>Casualty Analysis Studies</u>

Using on-line results and inputs from Project 010200, analyze casualty data to seek out correlations among categories of casualties, vessel damage sustained (in terms of type, location, and extent), preimpact conditions, and vessel characteristics (hull form and design, size, weight, etc.) using statistical methods and sound engineering judgment as necessary. Identify principal independent variables having significant influence in determining the type and extent of damage sustained. In this process, isolate, as one variable, a measure of the resistance of the hull or more generally a function which transfers impact conditions (e.g., impact type, preimpact energy, etc.) into vessel damage. Determine the magnitude and probability of damage on all types of vessels including tankers, cargo ships, novel craft, and unmanned barges.

050602. <u>Analytical/Experimental Evaluations</u>

Perform detailed analyses and testing as required to define the elements of the transfer function seeking specifically to identify the gross functional relationship between hull impact resistance and design variables which can be manipulated in a process of upgrading hull resistance. Using the results of Project 050601 with further inputs from Project 010200, develop profiles of casualties in terms of impact conditions and frequency of occurrence.

050603. <u>Assessment Methodology Development</u>

Develop the methodological relationships linking the results of these tasks permitting the effects of considered hull design alterations to be assessed in terms of expected changes in sustained damage for selected impact conditions and evaluated in accordance with the occurrence frequency of that impact condition.

LEVEL: Project NEXT LEVEL ITEM: Collision, Ramming, and Grounding Project Area ITEM NUMBER: 050700

TITLE: Vessel Traffic Management Technology

TECHNICAL RÉSUMÉ: The purpose of this project is to provide technological development of vessel traffic management systems to match individual port needs in reducing collisions, rammings, and groundings. The following tasks are included: (1) functional traffic management design and (2) support equipment requirements.

PROJECT INTERFACES: Supported by hazard trend and traffic projection information from 010100, by risk analysis capabilities developed in 010300 and 010400, by vessel characteristics information from 050400, and by human factors information from 050300.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
050701 Traffic Management Design	1000	500	200			1700
050702 Support Equipment Requirements	700	700	1000	1000	750	4150
Total Funds	1700	1200	1200	1000	750	5850

LEVEL: Tasks NEXT LEVEL ITEM: Vessel Traffic Management Technology Project PROJECT: 050700

050701. Functional Traffic Management Design

Define the control parameters and alternative control techniques for various levels of vessel traffic management systems and develop a basic design scheme reflecting a balanced approach to hazard control and throughput.

- Functional Design Information

  Provide the definition, collection, analysis, and evaluation of the broad base of functional and technical design information necessary to support the coherent development of vessel traffic services.

- Applied Traffic Management

  Examine, evaluate, and develop techniques, strategies and tactics for the management of traffic in the real-time harbor environment.

- Human Factors in Management

  Examine, evaluate, and develop techniques to relate the human factors associated with traffic management directly to the real-time management problem.

- Systems Effectiveness Parameters

  Examine, evaluate, and develop parameters and techniques to measure the effectiveness of both existing and planned traffic management systems. Use results of Project 050400, as applicable.

050702. Support Equipment Requirements

Identify, evaluate, and specify the hardware/software requirements integrated with human factors and traffic management techniques necessary to implement a vessel traffic management system.

- Surveillance Techniques

  Investigate various sensor equipments and techniques for cost-effective application to accurately fix vessel position and, in some cases, determine vessel direction and speed.

- Information Data Processing

  Develop techniques and hardware to enable the collection, processing, and display of vessel traffic data. A design specification and prototype hardware for the data processing and analysis aspects of a computerized family of vessel traffic systems suitable for implementation in the Port of New York, will be developed. Additionally the continued development of the computer-assisted PPI will provide an intermediate level of capability between the manual reporting systems and computerized vessel tracking capabilities.

LEVEL: Project NEXT LEVEL ITEM: Collision, Ramming, and Grounding Project Area ITEM NUMBER: 050800

TITLE: Bridge Protective Systems and Devices Guidelines

TECHNICAL RÉSUMÉ: The purpose of this project is to develop information regarding bridge protective systems and devices for field use in the Bridge Aministration Program. The project is subdivided into seven tasks as indicated in the tabulation below.

PROJECT INTERFACES: Supported by information on traffic projections and hazard trends coming from 010100 and by data on vessel maneuvering characteristics from 050400. Should be coordinated with 050300 in identifying improved aids to navigation.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
050801 Survey and Analysis of Bridge Protective Systems and Devices	75					75
050802 Bridge Navigation Parametric Assessment	25	100				125
050803 Improvement of Capability Standards			50			50
050804 Applicability of New Fendering Techniques		50				50
050805 Data Bank Systems Analysis				75		75
050806 Guideline Manual Development				25	50	75
050807 Bridge Fendering Workshop					50	50
Total Funds	100	150	50	100	100	500

LEVEL: Tasks NEXT LEVEL ITEM: Bridge Protective Systems and Devices PROJECT: 050800

050801. Survey and Analysis of Bridge Protective Systems and Devices

A survey and analysis of past, current, and proposed bridge fendering systems to assess performance. Feasibility schemes will also be required.

050802. Bridge Navigation Parametric Assessment

Using results of Project 050400, as available and applicable, define the maneuvering practices, capabilities, limitations of vessels and barge tows in transiting a bridge area. Determine the swept path of a range of vessels to define the clear span requirements for safe navigation. In concert with Project 050300, identify improvements in marking and navigation aids to reduce load on human operators.

050803. Improvement of Capability Standards

Improve and update capability standards of past, current, and proposed bridge fendering systems to accommodate the present and future needs to navigation.

050804. Applicability of New Fendering Techniques

Determine applicability of new fendering techniques to other areas, such as lock entrances, port entrances, harbor piers, marinas, etc., and identify future needs in these areas.

050805. Data Bank System Analysis

As a distinct part of the Coast Guard's integrated marine safety information system, establish a computerized data bank covering the criteria, standards, design techniques, assumptions made, and cost of fendering systems being designed and fabricated.

050806. Guideline Manual Development

Using results of above tasks, develop a guideline manual for field dissemination and use in bridge administration matters.

050807. Bridge Fendering Workshop

Using results from guideline manual, develop and organize a bridge fendering workshop.

LEVEL: Project NEXT LEVEL ITEM: Collision, Ramming, and Grounding Project Area ITEM NUMBER: 050900

TITLE: Short-Range Aids to Navigation

TECHNICAL RESUME: The purpose of this project is to establish an objective basis for the design of local systems of short-range aids to navigation, and to improve their effectiveness and reliability. The project concentrates on known principles and state-of-the-art hardware for early implementation, and upon the progressive application of research results, as they are obtained. Specific tasks include: (1) improving the reliability of the positions of visual aids to navigation; (2) defining requirements for, and the performance and benefits of aids to navigation; (3) improving the recognition and interpretation of signals; and (4) developing natural energy sources for use in aids to navigation.

PROJECT INTERFACES: Intensively supported by information from 050100, 050200, and 050300. Supported by 050400.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
050901 Positions of Aids to Navigation	875	580	335	225	160	2175
050902 Definition of Requirements, Performance, and Benefits of Short-Range Aids to Navigation			250	300	500	1050
050903 Recognition and Interpretation of Signals	100	100	250	250	200	900
050904 Alternative Power Source Evaluation	165	285	450	350	350	1600
Total Funds	1140	965	1285	1125	1210	5725

LEVEL: Tasks NEXT LEVEL ITEM: Short-Range Aids to Navigation Project PROJECT: 050900

050901. Positions of Aids to Navigation

Improve the reliability of the positions of visual aids to navigation. Develop improved methods for placing fixed and floating aids to navigation accurately on their assigned positions, and for auditing the positions of floating aids. Develop knowledge necessary to establish standards of accuracy for use in the placement and auditing of aids to navigation, and standard procedures for the selection of mooring components for floating aids. Develop improved methods of mooring floating aids to reduce probability of their movement from established positions.

050902. Definition of Requirements, Performance, and Benefits of Short-Range Aids to Navigation

Using results of Projects 050100, 050200, and (especially) 050300, establish relationships between requirements on navigational accuracy (as dictated by waterway, environment, vessel characteristics, traffic volume, desired rate of flow of traffic and the navigational performance achievable with alternative configurations of short-range aids to navigation. Develop methodology for designing local systems of short-range aids to navigation, relating performance of aids to navigation to reduction in risk. Develop methodology for defining benefits of aids to navigation in terms of safety (reduction in risk for accepted waterway and traffic conditions) or facilitation of transportation (improved economy/effectiveness of transportation at an acceptable level of risk).

050903. Recognition and Interpretation of Signals

Apply known scientific principles and state-of-the-art hardware to improve deficiencies in the recognition and interpretation of signals. Address known problems which inhibit the identification of aids to navigation and the ability to interpret, quickly and accurately, the message which is intended. Address additional problems which may be revealed by results of Projects 050100 and 050300. Conduct tests in real-world situations, and in conjunction with human factors research of Project 050300.

050904. Alternative Power Source Evaluation

Develop natural energy sources in short-range aids to navigation. Develop, test, and evaluate solar power for use in low-voltage aids that are now battery powered. Investigate alternative natural energy sources for higher power aids to navigation. Define the technical and economic impact of alternative power sources. Develop, test, and evaluate prototype for promising concepts.

LEVEL: Project NEXT LEVEL ITEM: Collision, Ramming, and Grounding Project Area ITEM NUMBER: 051000

TITLE: Radio Aids to Navigation

TECHNICAL RÉSUMÉ: The principal purpose of this project is to develop Loran-C for use as a precision, all-weather navigation system for use in harbor and harbor entrance areas (HHE). The project emphasizes development of the wide-area, coastal Loran-C system for maximum usefulness in the HHE, but includes also the development of methods of augmenting the wide-area Loran-C coverage where that proves necessary. The project includes, also, contingencies for future developments which may be necessary to satisfy requirements placed upon the Coast Guard, as the Loran-C system operator, by potential national acceptance of Loran-C for nonmarine uses. Finally, the project includes low-level efforts to remain current in radio-navigation technology, and to support the short-range aids to navigation system by improving the usefulness of visual aids to navigation as radar targets.

PROJECT INTERFACES: Supported by information from 050100, 050200, and 050300.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
051001 Definition of Requirements	30	10	10	150	300	500
051002 Maximize Usefulness of Wide-Area Loran-C for Precision Navigation	915	1175	1150	900	250	4390
051003 Augmentation of Wide-Area Loran-C System	225	175	150	--	--	550
051004 Loran-C User Equipment and Service	670	510	610	560	150	2500
051005 System Performance and Specifications	--	--	--	200	200	400
051006 Improve Availability and Utilization of Loran-C	10	120	120	220	220	690
051007 Miscellaneous Support of Aids to Navigation Programs	70	70	70	300	800	1310
Total Funds	1920	2060	2110	2330	1920	10,340

LEVEL: Tasks NEXT LEVEL ITEM: Radio Aids to Navigation Project Area PROJECT: 051000

051001. Definition of Requirements

Guided by information immediately available, including past experience with experimental shipboard guidance systems, develop an initial analysis and definition of the position and guidance information required for precision Loran-C navigation in harbor and harbor-entrance areas. Refine and improve this analysis, using the results of Projects 050200 and 050300, as well as information derived in the execution of other tasks of this project, to develop the general methodology for defining the quantity, quality, and form of position and guidance information required for safe navigation in any restricted waterway.

051002. Maximize Usefulness of Wide-Area Loran-C for Precision Navigation

Identify, quantify, and evaluate the effects of sources of error in the synchronization and propagation of Loran-C signals. Study the effects of interference. Investigate those Loran-C signal characteristics which are particularly important to precision navigation. Determine the magnitudes and sources of error in selected harbors and harbor-entrance areas, and assess the expected effects upon precisisn navigation. Considering the results in the light of initial analysis of requirements (Task 051001) and the characteristics of available user equipment, define (or produce the guidance for the definition of) those areas of the HHE where the wide-area Loran-C system can provide immediate, useful service, and the limitations on the use of that service.

Employ automation to minimize the effects of human factors as sources of error in the operation of Loran-C chains. Develop hardware, software, and doctrine needed to automate the calibration and the control of the synchronization of Loran-C chains. In the light of achievable improvements, and using the latest results available from Projects 050200 and 050300 and Task 051004, review and revise the earlier assessment of the limits on the usefulness of the wide-area Loran-C system in the HHE.

051003. Augmentation of Wide-Area Loran-C System

Using the existing experimental St. Marys River Loran-C chain, determine the maximum navigational performance achievable with a Loran-C minichain. Specify the chain characteristics required to achieve this performance. Evaluate, specifically, the ability of the minichain to satisfy navigation requirements on the St. Marys River. Evaluate differential Loran-C, and the use of supplementary low-powered secondary stations, and assess their ability to increase the accuracy and usefulness of the wide-area Loran-C system in the HHE.

051004. Loran-C User Equipment and Service

Develop prototype user equipment for precision Loran-C navigation to the extent necessary to define its performance requirements and demonstrate its effectiveness. Investigate and develop new techniques in signal processing for low-cost Loran-C receivers for precision navigation. Develop computer-based guidance systems to provide position and guidance information required for precision navigation. Develop requirements and methods to augment Loran-C user equipment with other sensors to improve the quantity and/or quality of guidance and the precision of navigation.

Develop methodology and calibrate Loran-C systems in areas of the HHE where the accuracy, precision, stability, and signal strength are adequate to meet navigational requirements or to provide useful service as a supplement to short-range aids to navigation. Develop techniques to produce charts, tables, and other information needed by users for precision Loran-C navigation.

051005. System Performance and Specifications

Develop a detailed comparison of the navigational performance achievable with the wide-area Loran-C system, and with alternative techniques for augmenting the wide-area system. Relate achievable levels of performance to requirements developed in Project 051001. Develop detailed system specifications for the Loran-C system, with alternatives for augmentation, and performance specifications for shipboard guidance systems of capability. Relate alternative levels of system complexity to achievable levels of navigational capability.

Assess the potential of Loran-C for use in navigation on stable and unstable inland rivers. If deemed technically feasible, define additional research and development needed to permit this use of Loran-C.

051006. Improve the Availability and Utilization of Loran-C

This task provides for the dev lopment of techniques for improving the availability and utilization of Loran-C for both marine and nonmarine users. It emphasizes, first the development of a capability for economical secondary-to-secondary and cross-rate Loran-C navigation, to improve the availability and provide greater selectivity of Loran-C LOPs for marine investigators and other users. It includes, also, the later development of Loran-C skywave navigation for marine and air users. It anticipates the imposition of requirements upon the Coast Guard, as Loran-C system operator, to develop improvements and additional capability in the Loran-C system to meet requirements of an increasing number of nonmarine Loran-C users.

051007. Miscellaneous Support to Aids to Navigation Programs

This task provides support to both short-range (AN) and radio (RA) aids to navigation programs. In support of AN, it includes the development of both active and passive radar echo enhancers, for installation on visual aids to navigation. In support of both RA and AN, it provides resources for a low-level, continuing evaluation of radio navigation technology and systems, and electronic positioning systems which have potential application to the positioning of visual aids to navigation. It provides, especially, for a continuing assessment of the development of satellite navigation systems whose service may become available to civil marine navigators.

3.6 STRUCTURAL FAILURES PROJECT AREA (060000)

3.6 STRUCTURAL FAILURES PROJECT AREA (060000)

The structural failures area encompasses basic strength factors and adequacy throughout the expected life cycle of marine structures including facilities and vessels.

3.6.1 Technological Trends

Structural failures are perhaps the most feared in that there is a high probability of catastrophic results--from both human and environmental safety standpoints. The Ship Structure Committee has and is advancing technology in the area of improving structural reliability of ships and marine structures. This activity should be continued with every effort to increase the Ship Structure Committee's role. However, the Coast Guard should not depend on this body as its sole technical support on structural matters.

Structural problems are difficult to define because full-scale testing-to-failure, so common in other industries, is not viable for large ships or marine structures such as offshore platforms. This results in the unfortunate situation of relying on operational failures for data. This situation is further complicated by the fact that critical failures cannot be analyzed in many cases because the vessel sinks. The legal and political complications of such analyses also vary among jurisdictions. Ships do not choose convenient locations to break up. With the advent of the VLCC's, the specter of a catastrophic structural failure is indeed awesome.

There is a general feeling that current computerized design sophistication is considerably superior to past techniques, allowing a more complete structural analysis to be made. Furthermore, there is a general belief that currently designed vessels should be considerably less susceptible to structural defects than older vessels. This is due to application of past research to new design. There is concern that increased size and special forms, such as shallow draft bulk carriers, have surpassed the state of the art of Naval Architecture. Further, under the trends of increasing economy of construction and operations, vessels are being designed with decreasing safety factors for the given loading conditions. This trend is causing concern because design knowledge surpasses knowledge of the actual input loading conditions. This, coupled with the increased use of high strength, corrosion-resistant materials, and increased high-latitude operations, point out an R&D need in this area. Increased use of sea-going barges is causing similar concern over structural adequacy of barges and barge-tows.

In addition to these trends, the VLCC's effectively mask operational stimuli (such as ship motion) from the master of the vessel. In fact, marine platform facilities are specifically designed to minimize motion and other stimuli. These stimuli were used to signal possible alterations in speed and/or course to control, to some degree, the loading situation imposed on the vessel. The extent of use of signals and their effectiveness are not known. Estimates range from zero to very significant. However, real concern is present merely by virtue of the fact that this control option is disappearing, not withstanding the effectiveness of these environmental stimuli.

Finally, a trend which is causing concern is the mounting pressure to reduce vessel and facility inspection requirements--a deterrent to efficient utilization. This trend is precisely counter to the anticipated need for more precise inspections in response to the design precision currently being employed. Considerable effort will be required to resolve these needs which, at present, appear to be in conflict. Certain facilities and vessels cannot be inspected by traditional means. Design procedures and inspection techniques must consider this condition.

3.6.2 Primary Anticipated Hazards

There is general agreement (tempered with considerable concern on the lack of capability in predicting structural response to varied sea states) that current computerized design techniques and state of knowledge are resulting in vessel designs which are considerably better than those of the not-too-distant past--even though traditional safety factors are being reduced in response to the increased knowledge. The real problem is the future. The concern is 5 to 10 years from now, given existing pressures for further reducing vessel and structure cost, coupled with radical departures in ship characteristics as in shallow draft and high-speed, fine-lines vessels.

The development of this branch of the fault tree utilized this type of thinking to identify exemplary anticipated hazard areas to focus RDT&E effort.

3.6.3 Project Area Research Strategy

While several specific hazard areas are defined in the branch development, two general hazard areas emerge.

(1) Hazards associated with potential inadequate designs for real-world operations

(2) Hazards associated with the inability to monitor vessel performance to minimize the risk of operations which exceed the design conditions.

Six projects are planned to minimize these hazards. The first project is aimed at developing more realistic seaway loading conditions to be commensurate with the vessel and offshore structure design sophistication. The second project is aimed at investigating material property criteria, testing procedures, and fabrication techniques to ensure appropriate life-cycle operational performance. The third project is intended to pull together the various approaches to structural strength evaluations of vessels to synthesize an approach tailored to the needs of the Coast Guard. The fourth project is aimed at improving vessel inspection techniques to ensure adequate vessel life-cycle performance. The fifth project investigates the subject of vessel maintenance and its improvement. The sixth project is aimed at determining the feasibility of utilizing sensors to provide the conning officer with appropriate stimuli to avoid environmental conditions which could result in structural stress levels exceeding the design conditions. In addition, an overall project (060100) to provide support for the Commandant, U. S. Coast Guard-sponsored Ship Structure Committee will assure interagency cooperation in this important area. This activity, which is supported by Maritime Administration, Navy, American Bureau of Shipping, as well as the Coast Guard, conducts a small but highly successful core research program and serves to focus at a high management level within each agency the needs and programs conducted by each agency in structural research.

There is no comparable activity in the other problem areas. This helps to avoid duplication among various agencies who conduct structural research for differing motives.

LEVEL: Project NEXT LEVEL ITEM: Structural Failure Project Area ITEM NUMBER: 060100

TITLE: Interagency Cooperative Research Project--Ship Structure Committee

TECHNICAL RESUME: The objective of this project is to provide for Coast Guard participation in and support of the Ship Structures Committee (SSC) research efforts.

PROJECT INTERFACES: Supported by traffic and hazard trend information from 010100, casualty information from 010200, and design requirement information from 060200.

Task Designation	Program Year 1	2	3	4	5	Total Funds
060101 Ship Structures Committee Support	200	205	210	215	210	1040
Total Funds	200	205	210	215	210	1040

LEVEL: Task NEXT LEVEL ITEM: Interagency Cooperative Research PROJECT: 060100

060101 Ship Structures Committee Support

Cooperative efforts through the Ship Structures Committee provides for leverage of Coast Guard R&D expenditures in areas of mutual interest. The SSC manages a diverse research program on materials fabrication, design, and response in seaways. On-going programs include extreme stress, motions, and load correlation efforts on the SL-7 container ships, studies of tank loading criteria for LNG, dynamic crack growth and arrest in structural steels, vessel damage resistance in collision and stranding situations, and underwater nondestructive inspection techniques. The main thrust of these programs are to improve vessel structural design. However, most of these efforts are also applicable to offshore structures and, in the areas of fracture mechanics and loads, criteria have been applied to nonship-form marine structures.

LEVEL: Project NEXT LEVEL ITEM: Structural Failure Project Area ITEM NUMBER: 060200

TITLE: Structural Loading Design Criteria

TECHNICAL RÉSUMÉ: The objective of this project is to develop information and data on more realistic and representative loading profiles and hull structural strength design criteria to be used in hull structure design analysis activities. Research approach consists of (1) study of design criteria now in use to determine the scope and extent of further investigations of loading phenomena, (2) experimental work with instrumented vessels to assemble a data base on loading effects, and (3) analysis and experimental work to establish consistent relationships between sea states and loading profiles for selected vessel types including offshore platforms.

PROJECT INTERFACES: Supported by and to be coordinated with information on seakeeping criteria from 070300. Also supported by data from 060700 and trend/casualty information from 010100 and 010200, and general information from 060100.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
060201 Analysis of Design Criteria	100	200	--	--	--	300
060202 Sea State Studies	--	50	100	500	300	950
060203 Loading Profile Description	--	--	50	500	200	750
060204 Loading Des. Crit.-Gt. Lakes	200	200	100	50	--	550
060205 Ocean Vessel Springing	--	--	--	50	100	150
060206 Large Shallow Draft Blk.Car.	--	--	50	--	--	50
060207 Mob.&Fixed Offshore Struct.	50	200	300	50	--	600
060208 High-Perf. Vessels	100	--	--	--	--	100
060209 Small Submersibles	--	100	--	--	--	100
Total Funds	450	750	600	1150	600	3550

LEVEL: Tasks NEXT LEVEL ITEM: Structural Loading Design Criteria PROJECT: 060200

060201 Analysis of Design Criteria

Conduct a critical study of hull strength design criteria. Relate these to critical assumptions regarding sea state conditions and resulting loading profiles. Utilizing inputs from 010200 postulate modes of structural failure of primary concern and relate these to loading assessment factors of concern--sea state conditions, route location of concern, vessel types, and so on. Determine maximum loads that vessels can survive after damage or flooding. Use the above information to define the scope and direction of further investigations (060208 effort) in the project. Results of SSC - Report 240 and SSC Project SR-227 - Load Criteria Study - must be considered. The SSC Project SR-247 - Critical Analysis Ship Casualty Data - should provide a survey of available failure data.

060202 Sea State Studies

Investigate techniques for describing and measuring sea conditions in selected ocean areas. Conduct necessary experimentation utilizing instrumented vessels of chosen, representative type, size, and route patterns to define wave condition and form inputs to the structural design process. Select and define a set of standard representative loading conditions for structural design analysis of vessels. Results of SSC Project SR-223 - Wave Loading Data Plan - should influence this task area. Inputs to NASA Sea Satellite and NOAA Data Bouy programs are also required. This work should be coordinated with 070306.

060203 Loading Profile Description

Identify and develop methodology (analytical and experimental) for determining the transfer function from sea state into loading effects on the vessel structure. Perform necessary experimentation to quantify these functions and to develop parameter relationships between loading profiles and vessel design parameters for vessel types of primary concern. Correlate with 070100 and 070200 to ensure that stability effects (vessel motion) and variations are accounted for in loading assessments. The SSC Projects SR-25 and SR-236 which relate full-scale data to models and computer analysis should be considered in task development.

060204 Loading Design Criteria--Great Lakes

Investigate hull structural loading associated with wave-induced vibration, and develop loading profiles for developing structural design criteria. The object of this effort is to provide design guidance in reviewing new large lake carrier designs. The full-scale instrumentation program conducted on several ore carriers to date should be continued with an attempt to better define representative wave spectra and correlated ship motions, springing and stresses with such spectra. This effort should benefit Tasks 060205 and 060206, i.e., ocean vessel springing; and large shallow draft bulk ocean carriers investigations.

060205 Ocean Vessel Springing

Investigate the springing response of large ocean-going vessels, especially those of high length-draft ratios. This effort should benefit from Task 060204, which provides a reasonable appraoch to determining peak stresses and strains experienced by vessels. Tasks 060204 and 060205 are critical to predicting crack propagation and crack arresting capabilities of ship designs. A survey study in hull flexibility is currently underway in SSC Project SR-239 and should provide a start to efforts in this area.

060206 Large Shallow Draft Bulk Carrier Design Criteria

Investigate the applicability of current design criteria for vessels with radical geometric parameters. This effort is to determine if a problem exists with such designs.

060207 Mobile and Fixed Offshore Structures

Investigate the state of the art of offshore platform structural design, fabrication, and maintenance criteria to develop adequate design review tools and procedures for both mobile and fixed structures.

060208 High-Performance Vessels

Conduct an audit of ongoing research programs on high-performance vessels, such as SL-7s, surface offset, planning and hydrofoil craft to determine gaps in information and knowledge which may require new research efforts in this area.

060209 Small Submersibles

Conduct a study of the state of the art in small submersible, ocean bottom completion units and other ocean bottom work capsules. This effort is to identify problem areas requiring further investigation.

LEVEL: Project NEXT LEVEL ITEM: Structural Failure Project Area ITEM NUMBER: 060300

TITLE: Structural Material Design Criteria

TECHNICAL RESUME: The objective of this project is to investigate and develop information on material test procedures and design criteria for new materials used in vessel construction (high strength steels, ferro-cement, aluminum, or plastic, for example). Research approach consists of (1) forecast and assessment of knowledge deficiencies related to new material, (2) testing and experimentation to generate new knowledge about materials properties in structural application of concern, and (3) trade-off studies of the impacts on the industry of various levels of design conservancy in the use of new materials.

PROJECT INTERFACES: Supported by information on material failure modes from 060100, design criteria from 060200, response data from 060400, vessel traffic and hazard trends from 010100, and casualty information from 010200.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
060301 Assess. Current Deficiencies	100	200	--	--	--	300
060302 Reinf. Concrete Des. Crit.	50	50	50	50	50	250
060303 Trade-Off Analyses	--	--	--	100	150	250
Total Funds	150	250	50	150	200	800

LEVEL: Tasks NEXT LEVEL ITEM: Structural Material Design Criteria PROJECT: 060300

060301 <u>Assessment of Current Deficiencies</u>

Based on on-line input, from 010100, 020100, and 010200, identify the various types of materials used for critical applications in vessel structures with emphasis on new or unusual materials. Identify the design criteria utilized in applying such materials and the standard testing methods used to verify their specific properties. Identify and define the operational environment in which these materials operate. Using further results form 010200, identify potential deficiencies in material design strength levels used, material property tests or interpretations of test results in raw material and as-fabricated conditions. Determine adequate design standards for aluminum and reinforced concrete. Increasing use of concrete in offshore structures; and aluminum in high-speed planning, hydrofoil, and surface effect craft require new design standards especially in the area of fatigue criteria.

060302 <u>Reinforced Concrete Design Criteria</u>

Investigate the use of reinforced concrete being used in huge off-shore platforms, storage tanks and hull material for LNG plants and storage vessels. Currently there are no design standards for this material in marine applications. Although considerable progress has been made by several classification societies, much work remains to be done before conservative information and knowledge is available to evolve meaningful regulations. Conduct destructive and nondestructive testing as necessary to verify identified deficiencies, and to compile accurate materials properties data. Make all findings known to the maritime technical community through mechanism developed in 010200. This should be a continuing effort and information should be coordinated with DOD-sponsored data banks.

060303 Trade-Off Analyses

Conduct trade-off studies to establish the impacts of alternative testing levels, quality, requirements, etc. on economics and level of design conservancy. Prepare risk level assessments versus costs in terms of critical failure mode and vessel type identified in 060200. SSC Project SR-222 - Material Trade-Off Study - should provide at least survey information in this area.

LEVEL: Project   NEXT LEVEL ITEM: Structural Failure Project Area   ITEM NUMBER: 060400

TITLE: Structural Response Criteria

TECHNICAL RÉSUMÉ: The objective of this project is to establish the methodologies and techniques by which vessel loading and materials design data can be interrelated to determine expected performance level and degree of design conservancy of structures. Research approach consists of (1) establishment of a consistent set of hull structure performance criteria, (2) critical review and assessment of the field of knowledge of hull structure design, and (3) synthesis of evaluation techniques tailored to Coast Guard needs using both analysis and modeling techniques.

PROJECT INTERFACES: Supported directly by 060100, 060200, and 060300.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
060401 Struct. Perf. Criteria	30	50	100	200	50	430
060402 Assess. State of Art	50	100	50	--	--	200
060403 Syn. of Eval.&Model. Tech.	50	50	--	--	100	200
Total Funds	130	200	150	200	150	830

LEVEL: Task NEXT LEVEL ITEM: Structural Response Criteria PROJECT: 060400

060401 Structural Performance Criteria

Using on-line input from 010200 and from 060200/060300, establish basic performance measures--criteria--for structural performance as a function of design. Formulate measures compatible with standard sea state conditions established in 060202 and applicable to the vessel type of immediate concern.

060402 Assessment of the State of the Art

Make a general analysis of the state of the art and current best practice in structural design. Determine to the greatest extent possible correlation between theoretical modeling and simulation approaches. Relate all the methodologies utilized to the structure performance criteria defined in 060401.

060403 Synthesis of Evaluation and Modeling Techniques

Utilizing information from 060402, synthesize structure evaluation methods at a level of resolution sufficient for Coast Guard evaluation requirements. Methodologies may be purely analytical or a combination of analysis and model simulation. Exercise the methodology with conventional classes of vessels to compile a body of evaluation data and calibrate the evaluation technique. Communicate all results of the maritime technical community through 010200. The results of SSC Projects SR-236 and SR-252 should be considered when they are available. Further, as an integral part of this effort, develop a long-term structural analysis capability to facilitate structural design reviews and provide an in-house capability to analyze unique or complicated structures. This objective will be attained through support and improvement of the GIFTS computer program.

LEVEL: Project NEXT LEVEL ITEM: Structural Failure Project Area ITEM NUMBER: 060500

TITLE: Vessel Inspection Requirements

TECHNICAL RÉSUMÉ: The objective of this project is to investigate techniques, equipment, and personnel training requirements for improved inspections to minimize structural failure occurrence due to degradation in service, improper design execution, construction faults, and so on.

PROJECT INTERFACES: Supported by information on NDT techniques from 060100, design requirements from 060200, and by maintenance methods information from 060600.

Task Designation	Program Year 1	2	3	4	5	Total Funds
06501 Eval. Current Techniques	50	75	125	50	--	300
060502 Ident. Crit. Requirements	--	--	50	150	50	250
060503 Trade-Off Analyses	--	--	--	100	--	100
060504 Compliance Factors Anal.	--	--	--	--	100	100
060505 Inspect. Stand. Prestr. Conc	50	100	25	--	--	175
060506 Inspect. Gde. Small Al T Boats	50	100	25	--	--	175
Total Funds	150	275	225	300	150	1100

LEVEL: Tasks NEXT LEVEL ITEM: Vessel Inspection Requirements PROJECT: 060500

060501 Evaluation of Current Techniques

Survey current inspection techniques, intervals, inspection points, and inspector qualifications as related to vessel structural safety. Survey structural design techniques and philosophies and on-line results and inputs from Project 060200 to identify critical structural elements and failure modes. Using on-line results and inputs from 010200, analyze vessel casualties involving structural failure to provide further identification and definition of key failure modes. Perform preliminary analyses to develop areas where current inspection practices and techniques are not commensurate with the anticipated failure modes or potential severity of a failure. Develop a measure of effectiveness by which improvements can be evaluated, e.g., reduction in failure probability. Current Coast Guard efforts in developing the VIIS system and the SSC Project SR-247 - Critical Analysis of Ship Casualty Data - will be important.

060502 Identification of Critical Requirements

Perform detailed analyses and testing as appropriate to define the key inspection requirements in these critical areas. Define the expected life-cycle performance of the elements involved to determine potential variations in inspection rigor required over the life of the vessel. Identify key indicators of structural weakening or other clues of impending failure. Develop, as necessary, equipment and techniques which can anticipate failures. Results of SSC Projects SR-232 - Structural Details Survey - and SR-233 - Structural Tolerance Survey - will be considered.

060503 Trade-Off Analyses

Perform trade-off analyses to identify the key inspection variables involved and to identify the relationships between the technical/economic requirements of alternative techniques and effectiveness potential, as well as other salient implications on merchant marine operations and Coast Guard inspector qualifications and manpower.

060504 Compliance Factors Analyses

Identify the implementation requirements and the required procedures to ensure compliance with each alternative.

060505 Inspection Standards for Prestressed Concrete

Develop inspection standards for determining the material condition of prestressed concrete used in marine applications. Determine nondestructive testing techniques.

060506 Inspection Guide for Small Aluminum "T" Boats

Develop an inspection guide for high-speed semiplaning aluminum passenger boats. Construction and design flaws aggravate the performance of aluminum in a corrosive high frequency impact environment where the reduced fatigue life of aluminum may become critical.

LEVEL: Project NEXT LEVEL ITEM: Structural Failure Project Area ITEM NUMBER: 060600

TITLE: Vessel Maintenance Analysis

TECHNICAL RÉSUMÉ: The objective of this project is to develop knowledge necessary to establish maintenance requirements/post maintenance inspections to minimize hazard risks from inadequate vessel structure maintenance. Scope of consideration runs from routine periodic maintenance operations performed by crew to and including major yard overhauls.

PROJECT INTERFACES: Supported by and to be coordinated with 040400.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
060201 Assess. Current Practices	100	100	50	--	--	250
060602 Assess Maint. Proc. Options	--	--	50	100	--	150
060603 Inspect.&Compl. Factors	--	--	--	50	100	150
Total Funds	100	100	100	150	100	550

LEVEL: Tasks NEXT LEVEL ITEM: Vessel Maintenance Analysis PROJECT: 060600

060601 Assessment of Current Practices

Survey current maintenance practices--preventive and restorative--applied to critical elements of vessel structures correlating the study with information from 060501. Using analytical and experimental techniques, identify areas where maintenance practices degrade the structural integrity of the vessel from its as-designed and as-classed condition. Using on-line results and inputs from Project 010200, analyze casualties data to seek out structural failure where inadequate maintenance was a contributing factor. Analyze key structural elements to identify sensitivity to observed maintenance practices. Perform testing as required to verify this sensitivity.

060602 Assessment of Maintenance Procedure Options

Formulate required alterations and restrictions to maintenance practices and/or frequency. Perform necessary analyses and testing to substantiate the formulation.

060603 Inspection and Compliance Factors Studies

Develop necessary procedures of maintenance monitoring and post-maintenance inspection/testing to ensure compliance with the above requirements.

LEVEL: Project NEXT LEVEL ITEM: Structural Failure Project Area ITEM NUMBER: 060700

TITLE: Structural Stress Management Feasibility Analysis

TECHNICAL RÉSUMÉ: The objective of this project is to define the potential for, and techniques of, managing stress levels in vessel structures as a means of reducing the potential for catastrophic structural failures during vessel operations. Current programs in the United States supported by MARAD and foreign supported by Det Norske Veritas should be considered in program development.

PROJECT INTERFACES: Supported by 060100, 060200, 060300, and 060400.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
060701 Stress Mgmt.Cont.&Info.Anal.	50	100	--	--	--	150
060702 Formul.&Anal.ofControl Meth.	--	50	100	150	50	350
060703 Feasibility Analysis	--	--	--	50	100	150
060704 Eval.Stress Mgmt. Equips.	50	100	50	--	--	200
Total Funds	100	250	150	200	150	850

LEVEL: Tasks NEXT LEVEL ITEM: Stress Management Feasibility Studies PROJECT: 060700

060701 Stress Management Control Action and Information Analysis

Using analytical techniques and on-line results and inputs from Project 060200, identify the critical vessel operational parameters which significantly affect vessel structural loading in a given sea state (e.g., speed, course, ballast condition). Perform preliminary evaluation of the effectiveness of manipulating each parameter as a means of reducing structural stress levels. Identify and calibrate key structural loading information sources which can be useful real-time indicators of hull stress levels.

060702 Formulation and Analysis of Control Methodologies

Identify alternative methodologies for establishing a stress management control loop composed of results of 060601 and the vessel master. Analyze the potential for each alternative. Identify key experimental data requirements for verification of above analyses. Correlate with Project 060200 for conduct of experiments. Conduct added experiments as necessary.

060703 Feasibility Analysis

Based on results of analyses, evaluate the feasibility of utilizing operational procedures as an effective means of stress management and develop alternative system specifications and developmental R&D requirements.

060704 Evaluate Existing and New Stress Management Equipments

There are a number of new analog and digital systems available for monitoring and computing bending moments, shear stress, etc.; however, the adequacy of these systems has not been determined. This task is to investigate the capability of these systems to provide reliable and useful information rather than misleading information.

3.7 FLOODING, CAPSIZING, OR FOUNDERING PROJECT AREA (070000)

3.7 FLOODING, CAPSIZING, OR FOUNDERING PROJECT AREA (070000)

This project area includes the part of the RDT&E program addressed to understanding vessel and offshore facility (deepwater port pumping and control platforms, oil and gas drilling, production and storage structures) stability phenomena and to assisting in the establishment of stability criteria.

3.7.1 Background

The stability of vessels under a variety of operating conditions has always been a primary topic of study and research in the maritime technical community. The state of the art is such that intact stability is not considered to be a significant research problem with respect to the conventional vessels of two decades ago. However, the evolution of the state of the art has not kept pace with changing vessel types. New types of ships such as containerships, LNG tankers, high-speed passenger and supply vessels, and dynamically supported craft have been developed. These are now being regulated as to stability requirements by extensions of criteria drawn up years ago. Furthermore, there is a well-defined trend for conventional vessels being operated in unconventional ways; for example, large tankers offloading in deep water to permit shallow water entry under part-load conditions, and feeder tankers, barges, and tow boats operating in sea conditions to provide this lighter service.

Another new area for concern is the stability of drilling ships, pipelaying barges, semisubmersible, submersible, and jack-up platforms used in the offshore oil and gas industry. Another related and new Coast Guard concern is the stability and structural integrity of fixed platforms in exposed ocean sites for deepwater ports. These control and pumping station platforms must withstand hurricane force wind and seas. These not only impose dynamic loads on the structure but generate huge bottom feeling waves that can scour away ground (ocean bottom) support, thus weakening the structure's resistance to seismic forces or other disturbances. This one aspect alone points out the need for knowledge of ocean bottom soil mechanics. Even though such structures may be designed to withstand storm and seismic-induced forces, the normal sea states will be continually acting on such structures and may induce greater stresses, and displacements where wave periods cause synchronous vibrations in such structures.

With respect to the science of stability assessment, new methods of high-speed calculation have come into use, making more deterministic means of evaluating stability possible for everyday use. The Coast Guard's commitment to participation in international organizations such as IMCO continue and increase. Recent research by the Coast Guard's Office of Research and Development has been in the following areas:

- capsizing and stability in following seas;
- stability of tugs and fishing vessels;
- seakeeping of small vessels in head seas.

The work on capsizing in following seas was finished in 1975, and resulted in fundamental advances in the knowledge base about this occurrence. A computer program which simulates a vessel's motions in following seas has been developed. At Hydronautics, Inc., in 1976, the tug and fishing vessel stability research concluded with recommendations for stability criteria. Part of the findings will be used at IMCO. The seakeeping and deck wetness study referred to above has shown that a widely used seakeeping computer program is probably not applicable to small vessels such as tug boats and fishing vessels. The results of this research will be used by the United States delegation to IMCO.

In the area of offshore structures, computer programs utilizing strip theory and finite element approaches can provide close approximations of structural vibrations and stresses in various sea states. One platform in the Gulf of Mexico was equipped with strain gages and accelerometers to correlate structural performance during long-term exposure in the ocean environment. These computer programs can also predict the performance and movement of such structures subjected to earthquakes; however, the transfer functions through wet ocean bottom soils are not known nor are the transfer functions of mixed sea states known. Thus, although basic analytical tools exist, more data and correlation work are necessary before analytical results can be considered reliably representative of the real world.

3.7.2 Primary Anticipated Hazards

The primary hazards addressed in this project area involve the lack of reasonable stability standards for new vessel types, offshore structures, and vessels employed in the offshore oil, gas, and mining industries. Current standards may have been satisfactory for conventional hull forms developed before 1960, but recent and continuing great departures from normal ship characteristics require the development of adequate standards. In addition, the increasing traffic in new ocean areas and in Arctic regions indicate a lack of experience in those areas that pose new requirements.

There is also concern over the adequacy of the stability information booklets provided the masters and mates and their ability to use them effectively in determining intact or damaged stability.

3.7.3 Project Area Research Strategy

Five projects are identified to deal with vessel stability problems. Even though these projects deal with ships, the techniques and data that will be developed are applicable to offshore structures, semisubmersibles, and other vessels with different characteristics. The first project "Intact Stability Criteria" is a comprehensive set of tasks to establish (1) a utilization plan for the stability simulation program, (2) a development of stability criteria for both conventional and newer types of vessels, and (3) an assessment stability analysis. The second project "Damaged Stability Criteria" involves the performance of research similar to that of the preceding project but concerning vessels in damaged condition. The third project addresses the subject of seakeeping and performs the research necessary to enable the Coast Guard to establish free-board requirements on the basis of seakeeping characteristics. The fourth project is concerned with crew performance aids and requirements for all aspects of stability. The fifth project covers the analysis of inspection requirements relative to stability.

LEVEL: Project NEXT LEVEL ITEM: Flooding, Capsizing, or Foundering Project Area ITEM NUMBER: 070100

TITLE: Intact Structure Stability Criteria

TECHNICAL RÉSUMÉ: The objective of this project is to examine the stability issues presented by new types of vessels and/or modes of operation utilzing a strong, practical simulation tool to be developed. The result will be the development of criteria for assurance of a safe degree of stability for all types of vessels and structures under foreseeable operating conditions. The approach will consist of (1) development of a validation and utilization plan for the stability simulator, (2) study of wave group probability, (3) study of intact stability requirements for all vessel types, (4) utilization of the simulator for stability assessments on an as-required, prioritized basis, and (5) application of the results, where applicable, to offshore structures and extension of the techniques developed to include such structures and other related vessels of abnormal configurations and characteristics.

PROJECT INTERFACES: Supported by vessel technology trend information from 010100.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
070101 Simulator utilization and validation	75	75				150
070102 Wave group probabilities	100	150	150			400
070103 Intact vessel stability requirement	75	150	150			375
070104 Simulator utilization			150	150	100	400
070105 Offshore structures (including semisub. drilling ves.)	100	150	100	75		425
Total Funds	350	525	550	225	100	1750

LEVEL: Tasks NEXT LEVEL ITEM: Intact Structure Stability Criteria PROJECT: 070100

070101. Simulator Utilization and Validation

Develop a plan for economically utilizing the stability simulation program developed during the 1969-1975 period at the University of California at Berkeley as a tool for appraising the stability of a variety of vessel types. This will involve considerable further validation of the program using models (container ships, LNG ships, tow boats, fishing boats are suggested) and the mapping out of an operating plan that recognizes the cost of operationg vis-a-vis the potential value of the output.

070102. Wave Group Probabilities

Investigate the probabilities of occurrence of wave "groups". The task involves two parts. First, using theoretical and experimental techniques, define the wave group characteristics necessary to cause capsizing of various types of ships. Second, using a theoretical approach, develop a means of predicting the occurrence of wave groups given the sea spectrum. The result of this research will be a sea-state predictive capability of vital importance to the development of regulatory positions regarding both the establishment of stability criteria and the appraisal of a vessel design with respect to it.

070103. Intact Vessel Stability Requirement

Using the most advanced knowledge of the subject and the simulator program, conduct research to establish stability requirements for both conventional and novel vessels. Systematically divide all commercial vessels (including offshore rigs, service vessels, high-load barges, etc.) into a schema of generic hull forms. Establish stability criteria for each of these observing a priority of importance as to which types of vessels present the greater hazard. Vessel types to be studied must include, but not be limited to: offshore supply vessels, barge, jack-up rigs, deck cargo barges, fishing boats, hydrofoils, surface effect ships, planers, catamarans, and the like. This also includes analyzing other forces affecting stability as: wind, cargo shifting, towing forces, free water, loss of maneuvering, etc.

070104. Simulator Utilization

Utilize the simulator program in accordance with the plan developed in 070101 in order to appraise the stability of vessels as required.

070105. Offshore Structures (Including Semisubmersible Drilling Vessels, Etc.)

Apply the results of the above to offshore structures such as deepwater port fixed pumping and control platforms. Extend the techniques developed above and apply and extend other techniques developed in the offshore oil and gas industry to these structures.

LEVEL: Project NEXT LEVEL ITEM: Flooding, Capsizing, or Foundering Project Area ITEM NUMBER: 070200

TITLE: Damaged Structure Stability Criteria

TECHNICAL RÉSUMÉ: The purpose of this project is to develop criteria for designing vessels and structures with adequate reserve stability and buoyancy. The research approach consists of (1) conduct of permeability studies, (2) development of damaged stability requirements, (3) modification of simulation program to include damage cases, (4) apply results, where applicable, to offshore structures, and (5) study of tanker segregated ballast distribution. Project outputs will be definitions of stability criteria and recommended stringency levels of damage stability regulation packages.

PROJECT INTERFACES: Supported by casualty information from 010100 and 010200, by damage analysis information from 050600 and 060200, by simulation capabilities from 070100, and by maneuvering casualty information from 050400.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
070201 Permeability studies	80	100				180
070202 Modify simulation program	75	75				150
070203 Emergency buoyancy methods			75	75		150
070204 Damaged stability requirements	50	100	100	75	50	375
070205 Tanker segregated ballast distribution	50	75				125
070206 Offshore structures and related vessels	75	100	100	50	50	375
Total Funds	330	450	275	200	100	1355

LEVEL: Tasks NEXT LEVEL ITEM: Damaged Structure Stability Criteria PROJECT: 070200

070201. Permeability Studies

Conduct a study of the permeabilities of various vessels and structures spaces. Included will be engine rooms of all types important to commercial vessels. Vessel types to consider will be: lash, general cargo, dry bulk cargo. Techniques used will be to survey the cargoes of a number of different vessels to determine what the cargo permeabilities are in practice. The results of doing this task will be an essential contribution to the body of knowledge necessary to the drafting of regulations in this field.

070202. Modify Simulation Program

Modify capsizing program to simulate a damaged vessel using tools from 070101.

070203. Emergency Buoyancy Methods

Utilizing information from 070204, determine if there are practical methods of providing additional buoyancy in an emergency situation. Possibilities to be examined are air bags or high expansion foam. Other concepts are to be generated and analyzed.

070204. Damaged Stability Requirements

Utilizing the simulation tools from 070104, establish upgraded damaged stability requirements for conventional passenger vessels. Extend these studies to other types of vessels as appropriate with special emphasis in the short term on offshore supply-type vessels.

070205. Tanker Segregated Ballast Distribution

The 1973 IMCO Marine Pollution Convention requires new tankers over 70,000 ton deadweight to be designed with a segregated ballast capacity of about 0.4 DWT. Conduct a study to determine the best distribution, around the vessel, of this capacity so as to take maximum advantage of this volume or protective space from collision and grounding damage but still satisfy longitudinal strength, tank size limits, stability and subdivision, and other requirements.

070206. Offshore Structures and Related Vessels

Apply the data and techniques developed in 070201 and 070204 above to offshore structures, semisubmersible drilling vessels, pipelaying barges and offshore construction vessels, and craft.

LEVEL: Project NEXT LEVEL ITEM: Flooding, Capsizing, or Foundering Project Area ITEM NUMBER: 070300

TITLE: Seakeeping Criteria

TECHNICAL RÉSUMÉ: The purpose of this project is to establish a practical seakeeping vessel criterion applicable to the full size/type range over which the Coast Guard has cognizance. A primary tool to be used in this effort is a simulation program developed by DTNSRDC. The approach to be taken in this project involves steps (1) further seakeeping program verification, (2) test the application of the program to larger vessels, (3) determine design seastates, and (4) establish freeboard requirements of various vessels as appropriate using a seakeeping criterion. Also, as a part of this project, and utilizing basically the same R&D tools, a further step is taken covering the development of standards for mooring systems.

PROJECT INTERFACES: Supported by, and to be coordinated with, structural loading information from 060200.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
070301 Seakeeping program verification and extension	100	100	75	100	75	450
070302 Analysis of water-on-deck phenomena	80	100	75			255
070303 Seakeeping basis for freeboard assignment	75	100	75	50		300
070304 Offshore structures and craft seakeeping and freeboard	100	100	125	100	75	500
070305 Mooring system standards			75	100	50	225
070306 Seastate determination	50	50				100
Total Funds	405	450	425	350	200	1830

LEVEL: Tasks NEXT LEVEL ITEM: Seakeeping Criteria PROJECT: 070300

070301. Seakeeping Program Verification and Extension

Complete the fishing vessel type hull research started at DTNSRDC. This involves further developing and refining a computer program for predicting vessel motions and deck wetness.

070302. Analysis of Water-On-Deck Phenomena

Utilizing the program developed in 070301 along with other analytical approaches and vessel motion programs, continue studies of the relationships among sea state, vessel motions, and deck wetness. The main purpose of these studies is to research the applicability of theory and available ship motions programs for predicting motion and deck wetness in the case of large vessels with high block coefficients (primarily tankers).

070303. Seakeeping Basis for Freeboard Assignment

If the studies above establish feasibility, proceed with determination of freeboard and intact stability requirements on the basis of vessel motions and seastate postulates for tankers and other types of vessels as priorities dictate.

070304. Offshore Structures and Industrial Platforms

Where applicable, apply the above data and techniques to evaluate offshore structures and industrial craft. Also apply analytical and computer techniques developed in the offshore oil and gas industry.

070305. Develop Standards for Establishing Adequate Moorings

This task is to build on and extend the deepwater port mooring research and development program in this area so as to include mooring systems for offshore oil, gas, and mining platforms. This will include a survey of existing and developing mooring systems to identify critical design elements and acceptable loads, and to develop engineering guidelines for attaining desired life and duty cycle for various moorings.

070306. Seastate Determination

Utilizing the results of work done by the Navy, determine what seastates to use in setting freeboard assignments for conventional and new vessel types. This work should be coordinated with 060202.

LEVEL: Project NEXT LEVEL ITEM: Flooding, Capsizing, or Foundering Project Area ITEM NUMBER: 070400

TITLE: Crew Performance Requirements

TECHNICAL RÉSUMÉ: The purpose of this project is to establish the training, informational, and performance requirements for vessel operating personnel with respect to stability. Three topics are addressed in the tasks: (1) development of a guide for the management of stability in an intact vessel, (2) development of standard operating procedures for stability management and control in intact vessels, and (3) development of damage control procedures and appropriate yraining and capability requirements for carrying them out.

PROJECT INTERFACES: Supported by 070100, 070200, and 070300. To be coordinated with 060700.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
070401 Stability and freeboard standards implementation requirements	50	100	150			300
070402 Stability management operating procedures			75	150		225
070403 Damage control procedures				75	150	225
Total Funds	50	100	225	225	150	750

LEVEL: Tasks NEXT LEVEL ITEM: Crew Performance Requirements PROJECT: 070400

070401. Stability, Freeboard Standards Implementation Requirements

Translate the results of stability, freeboard and ship motion studies and experiments into practical guides for masters and ships officers to safely operate their ships in various conditions of loading and in heavy seas.

070402. Stability Management Operating Procedures

Utilizing information from 070103, analyze the decision-making and knowledge requirements placed on vessel operating personnel to manage vessel stability safely as well as effectively. Provide guidelines as to capability requirements and tests or examinations by which assurance of meeting these requirements can be obtained. This work should be done in close conjunction with 060700, Structural Stress Management Feasibility Analysis.

070403. Damage Control Procedures

Utilizing information from 070204, analyze the decision-making and knowledge requirements placed on vessel operating personnel to manage stability and buoyancy in damaged vessels. Translate the results of stability, freeboard and ship motion studies, and experiments into a practical guide for masters and ships officers in various conditions of damage, loading, and heavy seas. Provide guidelines for training and for capability requirements and tests or examinations.

LEVEL: Project NEXT LEVEL ITEM: Flooding, Capsizing, or Foundering Project Area ITEM NUMBER: 070500

TITLE: Inspection Requirements

TECHNICAL RÉSUMÉ: The purpose of this project is to provide information and recommendations on inspection procedures which would mitigate vessel's loosing stability due to materiel degradation casualties. Three topics are addressed in the tasks: (1) development of inspection requirements for intact vessels, (2) development of inspection requirements for damage control procedures, and (3) development of inspection requirements for mooring.

PROJECT INTERFACES: Supported by 070100, 070200, and 070300. To be coordinated with 040300 and 060500.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
070501 Inspection requirements for intact stability standards	75	50				125
070502 Inspection requirements for damaged stability standards		50	50			100
070503 Inspection requirements for mooring standards			50	25		75
Total Funds	75	100	100	25		300

LEVEL: Tasks NEXT LEVEL ITEM: Inspection Requirements PROJECT: 070500

070501. Inspection Requirements for Intact Stability Standards

Utilizing on-line results from 060500 and 070103, identify the stability control factors relating to materiel degradation, survey inspection techniques and criteria pertinent to such control factors and recommend inspection requirements that would keep vessels in acceptable materiel condition with regard to stability.

070502. Inspection Requirements for Damaged Stability Standards

Conduct studies same as above for the topic of damaged stability. Include requirements for inspection of equipment used in damage control operations.

070503. Inspection Requirements for Mooring Standards

Utilizing results from 070305, identify the materiel condition factors affecting the integrity and capacity of mooring systems in various seastates. Determine inspection standards, techniques, and criteria are required to maintain mooring systems in acceptable materiel condition.

3.8 FIRE AND EXPLOSION PROJECT AREA (080000)

3.8 FIRE AND EXPLOSION PROJECT AREA (080000)

This project area encompasses a wide variety of programs attacking general fire and explosion hazards as they exist on vessels and in fixed facilities (port waterfronts, offshore platforms, etc.) over which the Coast Guard has safety cognizance. The area does not, however, cover spontaneous ignition of the cargo inside a full cargo tank in the absence of a shipboard fire or cargo spill. These hazards are covered in Project Areas 020000 and 040000.

3.8.1 Technological Trends

Fire research is not a new area of concern for the Coast Guard since it has led much of the basic and applied R&D in the fire and safety area in the past and is firmly committed to continuing the role in the future. Considerable improvement in fire resistance and fire-fighting techniques has been made--to the point where these hazards do not represent a large proportion of the marine casualty problem. This situation does not imply, however, that a relaxation in effort is justified. Rather, it is testimony to the diligence applied to attacking these hazards. Even though the occurrence and severity of vessel or facility fires and explosions may be low, these hazards are constantly present and, in fact are growing; they represent the highest potential for occurrence of all forms of casualties.

This in itself is justification for expanded R&D to reduce the potential for occurrence. The advent of VLCC's and the increased bulk carriage of hazardous chemicals not only increase this justification, but transform it into a necessity.

Similarly, the fire hazard picture in ports and other fixed facilities is growing as they get bigger and more complex in operation, and as they deal with greater amounts and kinds of hazardous substances.

3.8.2 Primary Anticipated Hazards

The main hazards leading to a fire or explosion casualty can be grouped in two categories.

(1) The presence of appropriate conditions (i.e., flammable, combustible, or explosive material and oxygen present in proper proportion together with an ignition source) leading to the onset of a fire or explosion.

(2) The inability to provide sufficiently quick and effective control means to stop the fire or explosion from reaching catastrophic proportions.

The largest single hazardous condition is a cargo fire or explosion. This is because the cargo may constitute 80 to 90 percent of a vessel's weight and, with many of the chemical cargoes, fire fighting is extremely difficult, even impossible. In this regard, virtually every project recommended in the earlier project areas has favorable impact. Project Area 130000 is aimed at minimizing transfer spills and, hence, the possible formation of flammable/combustible/explosive mixtures. Project Area 040000 is aimed at maintaining the safety of the cargo and the integrity of its containment system having the dual effect of reducing the potential for forming flammable/combustible/explosive mixtures interior and exterior to loaded tanks. For this potential to be realized, the vessel must remain intact. Project Areas 050000, 060000, and 070000 are directed toward this end.

Therefore, in addition to benefits resulting from direct reduction in reducing pollution, loss of life, and property damage, implementation of RDT&E efforts in these areas will promote significant reduction in fire/explosion potential by reducing the possibility of the cargo reactions in initiating a fire or explosion. These results are, however, not sufficient to eliminate fire and explosion concerns. The hazards of a noncargo-initiated fire and/or explosion remain significant--even if their effects do not reach and involve the cargo. If they do reach and involve the cargo, multiple results may be assumed: for example, a major cargo fire; a cargo tank explosion with or without subsequent cargo burning; massive release of hazardous materials to the air and/or water; and/or massive generation of toxic products of combustion common to many chemicals. In other words, catastrophic results may be assumed for any combustion occurrence allowed to get out of control.

In addition, while much of the previous research recommended in the program is aimed at reducing the potential for cargo spills, they cannot be reduced to zero. Significant hazards exist in the event of a spill of any material. If the material is susceptible to fire and/or explosion, an additional hazard is introduced for which there is currently little understanding--not only from the standpoint of fire fighting in large unconfined fires, but also in the mechanism of ignition, particularly in relation to large unconfined vapor clouds. The vapor ignition concern is not limited to spills; it is present also in large empty tanks--large tanks have experienced an abnormally high incidence of explosion during tank-cleaning operations.

Lastly, it should be recognized that the same trends toward carriage of more hazardous materials referred to above in connection with vessels exacerbates the fire/explosion safety problems in ports and other fixed facilities. The Coast Guard has an important share of the responsibility for safety here (in a complex interaction with local authorities and other Governmental agencies) and requires research support in keeping abreast of the hazard picture and the means at hand to control it.

3.8.3 Project Area Research Strategy

The strategic approach in this project area is based on subdividing the problem into vessel-related and facility-related issues. These, in turn, are further divided, where appropriate, into control-related and prevention-related issues. In this context, "control" refers to confining and fighting fires after they once start whereas "prevention" refers to not allowing them even to start. The latter involves the classical fire prevention approach of denying either fuel, ignition source, or both.

Six projects have been identified to address these topics. Two are concerned mainly with control for vessels: "Vessel Fire Fighting Technology and Procedures" and "Vessel Fire Resistance and Cargo Isolation". Two are concerned mainly with prevention in vessels: "Vapor and Fire Detection Equipment" and "Vapor Ignition". Finally, two are concerned with both control and prevention at fixed facilities: "Fire Prevention/Fighting at Offshore Facilities" and "Fire Prevention/Fighting at Conventional Ports".

LEVEL: Project NEXT LEVEL ITEM: Fire and Explosion Safety Project Area ITEM NUMBER: 0801C0

TITLE: Vessel Fire-Fighting Technology and Procedures

TECHNICAL RÉSUMÉ: The objective of this project is to help advance the state of the art of marine fire fighting as it pertains to commercial vessels and provide guidelines on the specific applicability of advanced fire-fighting systems and methods to vessels of interest. The research approach consists of: (1) analysis of fire/explosion casualty data to establish performance measures and to project future risk levels, (2) laboratory and field studies of advanced techniques to determine relative effectiveness, (3) development of ship-supported countermeasures for fires of large uncontained spills, and (4) detailed evaluations of crew capability requirements in fire fighting to develop assessment guidelines.

PROJECT INTERFACES: Supported by vessel and traffic trends from 010100, casualty information from 010200, and material information from 020100 and 020200.

Task Designation		Program Year					Total Funds
		1	2	3	4	5	
080101	Fire/Explosion Casualty Analysis	50	75	75	--	--	200
080102	Develop and Assess Fire-fighting Techniques Intact Vessel	50	75	100	75	75	375
080103	Ditto for Spilled Material	50	100	150	125	75	500
080104	Crew Performance Requirements	--	--	50	100	50	200
Total Funds		150	250	375	300	200	1275

LEVEL: Tasks   NEXT LEVEL ITEM: Vessel Fire-Fighting Technology and Procedures   PROJECT: 080100

080101 Fire/Explosion Casualty Analysis

Using on-line inputs from Project 010200, conduct detailed analyses of fire occurrence aboard vessels to determine modes of propagation and the effectiveness of countermeasures utilized in the past. Establish measures of performance of fire-fighting effectiveness with respect to generic parts of vessels and hazardous cargoes of concern as identified in 020200 and 010200 Utilize these measures of performance to project the probable range of effectiveness of present methods of fire fighting with respect to new forms of vessels and new types of cargo. Utilize these projections to define the areas in which advancements in the state of the art of fire fighting would be particularly cost-effective for commercial vessels. Maintain a continuing study of the advancing state of the art of shipboard fire-fighting techniques and add concepts to this realm as feasible as a part of this program.

080102 Develop and Assess Effectiveness of Vessel Fire-Fighting Techniques

Carry out an active program of tests and evaluation of fire-fighting techniques and methods. This task mainly includes laboratory and full-scale test work dealing with extinguishing agents and application equipment.

080103 Develop/Assess Fire-Fighting Techniques for Spilled Materials

This task addresses the problem of fighting fires in connection with spills. Two material categories are of major importance: LNG and hazardous chemicals. This task also covers the conception and development of shipboard-mounted equipment for combatting such fires. Conduct analysis, model, and full-scale experiments as required.

080104 Crew Performance Requirements

Utilizing inputs from Projects 080101 through 080103, make a comprehensive examination of the crew capabilties required to make correct deisions and correct utilization of advanced fire-fighting techniques. Establish generic types of emergency procedures to be carried out and the type of management direction required to utilize the advanced systems at peak effectiveness. From a study of human factors, develop fire shields, uniforms, life-support gear, sensing and informational apparatus for fire-fighting safety and effectiveness emphasizing special cargo hazards and products of combustion. Determine measures of crew performance in fire fighting amenable to testing and examination to establish adequacy.

LEVEL: Project NEXT LEVEL ITEM: Fire and Explosion Safety Project Area ITEM NUMBER: 080200

TITLE: Vessel Fire Resistance and Cargo Isolation

TECHNICAL RÉSUMÉ: The objective of this project is to define and assess ways to reduce the initiation and propagation of shipboard fires through vessel structural design, hull arrangements, and provision of cargo shielding. The research approach consists of (1) analysis of fire/explosion casualty data to establish performance measures for structural fire resistance, (2) studies of advanced methods and designs for cargo isolation and structural fire resistance, and (3) evaluation of structural and other materials.

PROJECT INTERFACES: Supported by 060300, 010200, 010100, and 020100.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
080201 Fire/Explosion Casualty Analysis	100	--	--	--	--	100
080202 Cargo Isolation and Structural Fire Resistance Studies	--	200	250	--	--	450
080203 Structural Materials Assessment	--	--	--	100	100	200
Total Funds	100	200	250	100	100	750

LEVEL: Tasks NEXT LEVEL ITEM: Vessel Fire Resistance and Cargo Isolation PROJECT: 080200

080201 Fire/Explosion Casualty Analysis

As a further aspect of 080101, analyze casualty data to establish a basis for assessing the effectiveness of structural fire resistance design with respect to hazardous materials of concern. Using these measures, characterize the adequacy of present design approaches. Utilizing on-line risk assessment from 010100, 020100, and 010200, establish required magnitude of improvement to be sought for and approaches to the securing of such improvements.

080202 Cargo Isolation and Structural Fire Resistance Design Studies

Assemble technical information covering the most advanced state-of-the-art in this topic including conceptual efforts of the Coast Guard staff. Analytically and experimentally develop and evaluate various methods of cargo tank isolation such as insulation, water flooding, and inerted zones around tanks. Account for trends to utilize new materials including nonmetals in vessel or tank construction. Investigate techniques for cargo safety when tanks are engulfed in flame with due regard to cargo environment and safety systems. Explore techniques for controlled burning and/or quick release of cargo to forestall explosion. Develop and provide design guidelines and criteria for methods considered promising.

080203 Structural Materials Assessment

Conduct analytical and laboratory assessments of the fire-related properties of materials being used or proposed for use in vessels for structure, compartmentation, or furnishing purposes. This should be considered as a continuing activity.

LEVEL: Project NEXT LEVEL ITEM: Fire and Explosion Safety Project Area ITEM NUMBER: 0803C0

TITLE: Vapor/Fire Detection Equipment

TECHNICAL RÉSUMÉ: The objective of this project is to provide a basis for setting requirements for fixed and portable detection systems for the reliable and timely indication of concentrations of vapors from toxic, flammable, or explosive cargoes to reduce incidence of cargo-induced fires/explosions and of crew asphyxiation from toxic vapors. The research approach will consist of (1) study of characteristics of vapors of interest from the standpoint of detectability, (2) establishment of detection equipment performance requirements of various stringency levels, (3) analytical/experimental evaluations of present and developmental equipment performance, (4) studies of technical and economic feasibility of various types of detection equipment, and (5) a detailed study of operating and inspection factors of detection equipment. Project outputs will be a continuing body of general knowledge and data regarding detection equipment for quick reference purposes plus guidelines on feasibility and operational factors with respect to particular systems of interest to the Coast Guard.

PROJECT INTERFACES: Supported by 010200, 020200, 080100, 080200, 080300, and 080400.

Task Designation		Program Year					Total Funds
		1	2	3	4	5	
080301	Cargo Vapor Characteristics	100	100	--	--	--	200
080302	Basic Equipment Requirements	--	75	100	--	--	175
080303	Analytical/Experimental Evaluations	--	--	50	200	--	250
080304	Operational and Inspection Factors Analysis	--	--	--	50	75	125
Total Funds		100	175	150	250	75	750

LEVEL: Tasks NEXT LEVEL ITEM: Vapor/Fire Detection Equipment PROJECT: 080300

080301 Cargo/Vapor Characteristics

Carry out studies in conjunction with and as a part of Projects 020200 and 080400 to identify hazardous cargo concentrations with respect to materials identified in 010200 series projects to be of present or future concern. Analyze these materials by type classes and describe those characteristics of each class pertinent to the development and operation of sensing/warning devices. Particular emphasis should be on time constants involved in the onset of fires and explosions in order to establish response time of detection equipment. Characteristic unique signatures of each material as to its presence and concentration level are equally important in these studies. The studies should be designed to produce a comprehensive data base for the conception and evaluation of detection devices associated with each material.

080302 Basic Equipment Performance Requirements

Utilizing inputs from Task 080301 and the 080100 and 080200 Projects establish the basic performance requirements for vapor detection equipment at various levels of risk reduction with respect to each hazardous material concerned. Measures of performance should be defined and utilized for such factors as speed, discrimination, signal strength, and reliability/maintainability of detection equipment. The outputs of these studies comprise basic technical information for the drafting of specifications for detection equipment at various stringency levels and the compiling of inspection and maintenance procedures.

080303 Analytical/Experimental Evaluations

Using both analytical and experimental techniques determine the actual performance characteristics of present and developmental detection systems. Define the inherent limitations and problem areas connected with each type and technique such as sensitivity to the marine environment, requirements for very high quality maintenance procedures, and so on. Provide assessments of these capabilities with respect to each class of detection equipment as a basis for drafting specifications and also as a means for describing required improvements in performance in order to satisfactorily reduce risk levels.

080304 Operational and Inspection Factors Analysis

Carry out analysis studies to establish the operational reliability and maintenace factors associated with using the different classes of detection equipment of interest. Operational factors in this context are concerned primarily with crew capabilities required to properly use and maintain the detection equipment on board. If certain classes of equipment require highly specialized crew capabilities these must be defined, described, and means of assessing and testing for the existance of those capabilities developed. Studies of reliability factors involve use of reliability concepts in forecasting the failure tendencies of detection equipment and developing maintenance and testing procedures to forestall the occurrence of failures. Study of reliability factors will be utilized in determining test and inspection cycles to be employed by the Coast Guard in obtaining assurance of vessel compliance.

LEVEL: Project NEXT LEVEL ITEM: Fire and Explosion Safety Project Area ITEM NUMBER: 080400

TITLE: Vapor Ignition

TECHNICAL RÉSUMÉ: The objective of this project is to develop information on concepts and methods for minimizing the ignition of hazardous vapor clouds in both in-tank and out-of-tank conditions. The research approach consists of (1) a basic examination of ignition mode knowledge to identify problem areas, (2) experimental studies of ignition mechanisms, (3) conception and evaluation of ignition prevention means, and (4) compliance studies relative to crew capabilities and safety procedures.

PROJECT INTERFACES: Supported by 010200 and 080100.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
080401 Vapor Ignition Analysis and Experimentation	75	180	100	100	--	455
080402 Concept Evaluation of Ignition Prevention Procedures & Equipment	--	--	100	100	50	250
080403 Crew Capabilities and Procedures	--	--	--	50	75	125
Total Funds	75	180	200	250	125	830

LEVEL: Tasks NEXT LEVEL ITEM: Vapor Ignition PROJECT: 080400

080401 Vapor Ignition Mode Analysis and Experimentation

Extend the studies under Task 080101 to provide a study of casualty data for the purpose of characterizing modalities of vapor ignition by class of hazardous materials. Analyze and update existing studies on vapor ignition especially those concerned with tank-cleaning instruments. Based on these studies and projections of anticipated risks from 010200 series projects, identify current and anticipated problem areas relative to modalities of inadvertent ignition of vapor clouds and define possible approaches to solutions of these problem areas. Develop experimental procedures for studying modes of vapor ignition with respect to various materials of interest. Perform systematic experiments to define the vapor ignition process and various means for minimizing its occurrence including inerting and cleaning procedures coupled with precautionary measures on the part of crew. Extend experimental work to include ignition modes of vapor accumulations in pump rooms and work spaces and the ignition unconfined vapor clouds such as might accumulate in a spill or from normal handling operations.

080402 Conception/Evaluation of Ignition Prevention Procedures and Equipment

Assemble comprehensive data and information on currently used ignition prevention methods and procedures. Based on results of Task 080401, conceive additional methodologies and/or equipment to further reduce the risk of inadvertant vapor ignition. Carry out analytical and laboratory studies to evaluate the impact on risk levels and costs of implementing these methodologies at various levels of stringency and completeness as inputs to subsequent cost effectiveness evaluations.

080403 Crew Capabilities and Procedures

Carry out detailed studies of crew capabilities and operational procedures connected with vapor ignition minimization measures. Since attitudinal factors will probably be important in minimizing ignition sources carry out studies of training requirements and indoctrination factors that would reveal the degree of awareness and concern coupled with required factual knowledge of the subject for adequate ignition pressures as far as crew performance is concerned. Recommend methods of inspection and testing for these factors.

LEVEL: Project NEXT LEVEL ITEM: Fire and Explosion Safety Project Area ITEM NUMBER: 080500

TITLE: Purging Methods

TECHNICAL RÉSUMÉ: The objective of this project is to examine and risks and problems involved in purging closed spaces of hazardous fumes and develop a basis for establishing requirements and procedures for more effective means of doing so. The project applies to purging cargo tanks, machinery spaces, voids in the event of explosive mixture formation or accumulation of toxic vapors. Research approach consists of (1) analysis of current practices and their technological basis to determine effectiveness and define future problem areas, (2) experimental studies to establish effectiveness and feasibility of new methods, and (3) studies of crew capability requirements in this regard.

PROJECT INTERFACES: Supported by 020200 and 080100.

Task Designation		Program Year					Total Funds
		1	2	3	4	5	
080501	State-of-the-Art Analysis	--	--	75	--	--	75
080502	Experimental Studies of Effectiveness	--	--	50	100	--	150
080503	Crew Capability Requirements	--	--	--	--	50	50
Total Funds		--	--	125	100	50	275

LEVEL: Tasks NEXT LEVEL ITEM: Fire and Explosion PROJECT: 080500

080501 State-of-the-Art Analysis

Carry out a critical analysis of the current state of the art of purging closed spaces with particular reference to the status respecting newer hazardous materials entering or expected to enter maritime traffic. Survey these practices with respect to equipment, procedures, and gas-free criteria for cargo tanks, pump rooms, and voids. Study casualty data (coordinating with 080101) to establish procedural or equipment problem areas leading to accidents. Forecast future problems that may arise with respect to safe and proper purging methods, including possible environmental impacts arising from purging to the atmosphere.

080502 Experimental Studies of Effectiveness

Develop an experimental method for investigating the effectiveness of purging methodologies. With inputs on materials of concern developed in 020200, use the experimental tool to evaluate the effectiveness and costliness of current purging procedures. Develop concepts for advanced or novel methods--especially for purging newer types of hazardous material fumes--and evaluate effectiveness and costs for these utilizing experimental methods. Provide cost effectiveness and technical feasibility information regarding possible improved methods and equipment for purging.

080503 Crew Capability Requirements

Analyze purging methodologies to identify required crew capabilities in terms of knowledge, experience, and skills. Define procedures in terms of these attributes coupled with judgmental decision-making required. Identify various means of inspection and testing to establish that the capability requirements are satisfied and are present.

LEVEL: Project NEXT LEVEL ITEM: Fire and Explosion Safety Project Area ITEM NUMBER: 080600

TITLE: Fire Prevention/Fighting at Offshore Facilities

TECHNICAL RÉSUMÉ: Many of the other projects in Project Area 080000 will yield knowledge pertaining to the offshore facility fire prevention and fighting. However, the unique features of such facilities--their isolation from land-based fire-fighting capabilities and the potentially serious consequences of a fire--require a specific look at fire fighting. A program is required to

(1) Analyze past port operations and offshore platform operations to identify potential for and nature of fire incidence.

(2) Establish profile for credible fire incident.

(3) Identify and synthesize alternative techniques for fire fighting--including buoy based, tender based, and tanker based.

(4) Perform tradeoff studies to assess cost effectiveness implication of alternative techniques.

PROJECT INTERFACES: Supported by 010100, 010200, 020200, and 080100.

Task Designation	Program Year 1	2	3	4	5	Total Funds
080601 Casualty Analysis and State-of-the-Art Study/ Critique	100	100	--	--	--	200
080602 Synthesize Fire-Fighting Techniques & Equipment	--	--	50	100	100	250
Total Funds	100	100	50	100	100	450

LEVEL: Tasks NEXT LEVEL ITEM: Fire Prevention/Sighting at Offshore Facilities PROJECT: 080600

080601 Casualty Analysis and State-of-the-Art Study/Critique

Analyze casualties involving fires and explosions at offshore facilities to build an information base on the topic. By critically reviewing this information, develop credible fire incident profiles as a basis for taking further regulatory steps. This includes hazards related to blow-outs in drilling and well reworking operations.

080602 Synthesize Fire-Fighting Techniques and Equipment

In addition to isolation of fire and explosion-prone areas, such as pump and machinery rooms, the development and synthesis of detecting, inerting, and sprinkling systems and techniques unique to offshore platforms and vessels must be achieved to meet the hazard profiles defined above.

LEVEL: Project NEXT LEVEL ITEM: Fire and Explosion Safety Project Area ITEM NUMBER: 080700

TITLE: Fire Prevention/Fighting at Conventional Ports

TECHNICAL RÉSUMÉ: The purpose of this project is to develop criteria, guidelines, and equipment for handling the Coast Guard's responsibilities for controlling fire at port facilities. The project consists of two tasks: (1) casualty and state-of-the-art analysis to identify critical factors and form the basis of a guidelines manual for COTP use and (2) equipment development and testing.

PROJECT INTERFACES: Supported by 010100, 010200, 020200, and 080100.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
080701 Casualty Analysis and State-of-the-Art Study	--	--	100	15	--	115
080702 Equipment Development and Testing	--	--	100	100	50	250
Total Funds	--	--	200	115	50	365

LEVEL: Tasks NEXT LEVEL ITEM: Fire Prevention/Fighting at Conventional Ports PROJECT: 080700

080701 Casualty Analysis and State-of-the-Art Study

Carry out an analysis of fire/explosion casualties in port facilities. Through survey techniques, expand the information base with data on COTP procedures and decisions relative to fire hazards in ports. Based on these resources, prepare a set of guidelines for COTP use. This includes safety procedures for the stowage, handling, movement, and security of hazardous cargoes.

080702 Equipment Development and Testing

Perform equipment development and testing as needed to support the port safety program with respect to fire and explosion hazards.

3.9 CREW/PASSENGER SAFETY AREA (090000)

3.9 CREW/PASSENGER SAFETY AREA, 090000

This project area includes the sources of all conditions--rooted in either casualties or routine operations--that produce hazards risking the life or security of crew members and passengers of ships and offshore facilities, including fixed platforms for deepwater ports, structures, vessels, and craft related to the offshore oil, gas and mining industries.

3.9.1 Background

The principal trends causing increased concern about crew and passenger safety are the general increase in shipping activities involving numerous hazardous materials, and the increasing ship dimensions with disproportionate powering and maneuvering capabilities. Other trends increasing this concern for safety are: increased operations in cold regions (e.g., extension of the Great Lakes' operating season and the buildup of activity in connection with oil exploration, production, and transportation in Alaska); increased offshore industrial activities at increasing distances from shore and in waters exceeding 600 feet in depth (these activities involve oil and gas exploration, production, and transportation--deepwater port development in areas exposed to ocean waves and wind forces); high performance ships and craft; and the increasing use of small submersibles for research and industrial underwater work.

3.9.2 Primary Anticipated Hazards

Two principal sources of hazards to passengers and crew members must be considered. The first is vessel and facility casualties or offshore platform casualties of any sort since they present hazards to crew members and passengers. The second is a large variety of routine tasks or activities associated with seagoing but which fall in the category of hazardous occupational factors. Of particular concern with occupational factors is the unknown effects of chronic exposure to low concentrations of fumes of "nontoxic" and toxic substances. Does chronic exposure to some substances affect the judgement and safe performance of crew members?

A crew member whose judgment or physical performance is impaired because of such exposure can endanger the safety of the vessel and fellow crew members.

3.9.3 Vessel and Facility Casualty Hazards

Generally all of the previous projects identified in the RDT&E program have beneficial results in this problem area--either by reducing the frequency of casualties or by reducing the severity of such casualties. However, since the chance for casualties will always exist, passenger and crew survival and evacuation should still be a major concern. This is particularly true for vessels and facilities carrying hazardous materials. Crew survival and evacuation in a sea of flames, toxic gases, and products of reactions or explosive gases represent extreme hazards to both crew and rescue forces. Transoçean passenger traffic has declined to a low level; however, a resurgence in cruise operations in foreign flag vessels has been increasing, and the passenger and cruise activity to Alaska has been increasing. The remainder of our concern involves ferry and excursion boat service. The use of high speed semiplaning crew boats serving the offshore industry and interisland travel in the Hawaiian Islands. There still exists a major concern for passenger safety for the Coast Guard. This concern is justified in that many passengers are not sailors and there may very well be language barriers on some foreign flag vessels. This makes it imperative that all emergency procedures involving passenger safety be simple and easy to follow in a high stressful situation by landsmen in an alien environment.

3.9.3.1 Occupational Hazards. There are many traditional seagoing jobs which present occupational hazards and have from time to time occasioned injury or death to crew members because of inadequate training, equipment, or other safeguards. However, most of these jobs have not altered their nature for the worst because of the impact of technological change trends referred to above. One exception to this is hazards associated with exposure for various reasons to toxic cargo fumes. The trend to increased traffic with hazardous liquid cargoes and the introduction to that traffic of new cargoes have exacerbated this problem. Most of the faults falling in this general hazard category are countered by other projects in the RDT&E program. One, the development of life support equipment and procedures for safety in a toxic fume environment has been identified on the tree as being unique to this problem area. Another exception is the increasing number of large ships and offshore platforms which introduce very high freeboards which introduce increased hazards to evacuation or abandon ship operations. Further, the increasing use of small submersibles for research and underwater industrial work introduces new hazards as well as search and rescue problems. The use of divers in offshore industrial efforts imposes hyperbaric hazards and emergency treatment and evacuation procedures. The need for operations and diving equipment standards provides another area for Coast Guard concern.

3.9.4 Project Area Research Strategy

This area will be covered by nine projects as follows: 090100. Survival System Analysis; 090200. Preabandonment Casualty Response; 090300. Assessment of Group Survival Equipment and Procedures to Meet the Criteria Developed in 090100; 090400. Individual Survival Equipments; 090500. Evaluate the Development of Survivor Retrieval Equipment and Procedures; 090600. Development of Underwater Search and Rescue Procedures and Equipment; 090700. Establishment of Survival System Requirement for Small Submersible; 090800. Personnel Vapor Protection; 090900. Establishment of Industrial Diving Standards for Operations and Diving Equipment.

LEVEL: Project NEXT LEVEL ITEM: Crew/Passenger Safety Project Area ITEM NUMBER: 090100

TITLE: Crew/Passenger Survival Systems

TECHNICAL RÉSUMÉ: The objective of this project is to develop criteria for evaluating survival equipment and procedures and provide concepts and evaluations for survival means in hazardous marine casualty situations. The research approach consists of (1) definition of survival system requirements assuming abandonment concurrent with a massive cargo spill, (2) evaluation of existing knowledge and capabilities, (3) conception and experimental development of new survival systems containing needed equipment, (5) studies considering survival problems involving passengers, and (6) studies of compliance factors related to new systems.

PROJECT INTERFACES: Supported by 010100, 010200, 020200, 020300, 040100, and 080300.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
090101 Survival System Analysis	100	50	25	25	25	225
090102 Casualty Profile Development	50	100	50	50	50	300
090103 Performance Criteria	25	75	50	50		200
090104 Performance Testing Requirements		50	50	50		150
090105 Establish Life Support Requirements		50	75	75		200
Total Funds	175	325	250	250	75	1075

LEVEL: Tasks NEXT LEVEL ITEM: Crew/Passenger Survival Systems PROJECT: 090100

090101 Survival System Requirements Analysis

Using on-line inputs from 020200 and 010200, define survival system and procedure requirements imposed by the possibilities of abandonment in massive spills. Select a priority list of cargo types for study from inputs from 020200 and 020300 Establish the critical factors of survival system performance through systems analysis procedures with respect to each critical cargo type including crew capabilities and knowledge, egress factors, and life support requirements in all pertinent environments. Survival systems for passengers require particular concern especially when language barriers may exist on foreign vessels operating out of U. S. ports. This task is completed except for passenger survival studies. Another area requiring study is offshore structures, and vessels involved in the oil, gas and mining industry.

090102 Casualty Profile Development

Casualty profile development will define the casualty scenario for each type of incident on each type of vessel. An analysis of the casualty scenario will indicate the casualty conditions on the vessel when the survival system will be required. This task will evaluate the effectiveness of the casualty response system and provision in developing the casualty scenarios. Correlation of casualty scenarios for various sizes of vessels and various types of vessels will lead to the determination of the needs for the types of survival system and the environment in which they must perform. Ship design innovations will be considered, as well as offshore structures and craft related to deepwater ports and the oil, gas and mining industries.

090103 Performance Criteria

Performance criteria will utilize the results of Task 090102 to develop the performance criteria for the survival equipment on each type of vessel. The work will include an initial evaluation of the effectiveness of improvements in other areas of casualty response capability such as fire fighting or flooding control.

090104 Performance Testing Requirements

Performance testing requirements will determine the methods and procedures to be utilized in measuring the effectiveness of the survival equipment against the performance criteria.

090105 Establish Life-Support Requirements

Investigate performance requirements for life-support equipment in spaces where toxic vapor accumulations may occur. Also investigate the need for life-support equipment for crew members exposed to explosions, fire, and other hazardous environments. This task should be supported by project areas 040000 and 080000. However, this task is limited to abandonment requirements from hazardous environments.

LEVEL: Project NEXT LEVEL ITEM: Crew/Passenger Safety Project Area ITEM NUMBER: 090200

TITLE: Preabandonment/Casualty Response

TECHNICAL RÉSUMÉ: The object of this project is to develop procedures and equipment to respond to marine casualty profiles evolved in Task 090100. Such response could obviate the need to abandon or delay the time before abandonment becomes a necessity. Navy and Coast Guard damage control experience should provide an excellent source of information for this project.

PROJECT INTERFACES: Supported by hazard trends and casualty data from 010100 and 010200, by stability information from 070100 and 070200, and by 090100.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
090201 Casualty Response	80	80	60	20		240
090202 Casualty Response Training Requirements		20	40	30		90
090203 Damage Control Equipment Requirements			20	50	40	110
Total Funds	80	100	120	100	40	440

LEVEL: Tasks NEXT LEVEL ITEM: Preabandonment/Casualty Response PROJECT: 090200

090201 Develop casualty response information booklets patterned after Coast Guard and Navy manuals such as: Damage Control Books, Casualty Control Manuals, Ships Information Books and Repair Party Manuals. This information should be developed for the vessel including expected casualty profiles which provide the Master and Engineering Officer the means to quickly respond to casualties and ascertain the survivability of their vessel, i.e., determine the damaged stability and margin of buoyancy and measures to be taken to enhance the survivability of their vessel. This task includes offshore structures, vessels and craft related to the oil, gas, and mining industries.

090202 Establish casualty response training procedures.

090203 Determine the requirements for damage control equipment and materials which would be needed to respond to casualties.

LEVEL: Project NEXT LEVEL ITEM: Crew/Passenger Safety Project Area ITEM NUMBER: 090300

TITLE: Group Survival Systems

TECHNICAL RÉSUMÉ: The objective of this project is to evaluate existing group survival equipment to meet the performance criteria developed in Project 090100. Also included will be tasks to correct problem areas uncovered in currently required survival systems.

PROJECT INTERFACES: Supported by 010200 and 090100.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
090301 Inclined Plane Feas. Study	50	70				120
090302 Wire Rope Sheave System	50	75	50			175
090303 Cold Engine Start Invest.	50	50				100
090304 Life Raft Stability Invest and Testing	50	75	150	100		375
090305 Full Scale Tests and Evaluations			100	200	150	450
Total Funds	200	270	300	300	150	1220

LEVEL: Tasks NEXT LEVEL ITEM: Group Survival Systems PROJECT: 090300

090301 Inclined Plane Feasibility Study

Conduct a feasibility study of inclined plane/float-off launching techniques for life rafts.

090302 Wire Rope Sheave System

Investigate wire rope and winches for lifeboats. The number of failures in boat falls indicate that design, maintenance, and inspection methods and standards are inadequate. The wire rope, sheaves, and winches should be investigated as a system in a corrosive environment with unusual operating and testing requirements peculiar to this application.

090303 Cold Engine Starting Investigation

Investigate the reliability and maintainability problems related to lifeboat engines. Also investigate the problems related to cold engine start-up in cold regions. This problem is becoming increasingly important in view of the increased exploration production and transportation of oil in Alaskan waters. The extended Great Lakes sailing season will also entail cold engine starting requirements.

090304 Life Raft Stability Investigation and Testing

Investigate raft stability and control problems, and new equipment and concepts which promise to alleviate these problems. Several new innovations, such as ballast water bags and membrane skirts, should be tested and evaluated.

090305 Full Scale Tests and Evaluations

Conduct full scale tests and evaluations of existing and newly developed prototype rafts evolved from Task 090304 or new concept rafts. Such tests should be conducted in cold regions as well as in a range of extreme seastate environments.

LEVEL: Project NEXT LEVEL ITEM: Crew/Passenger Safety Project Area ITEM NUMBER: 090400

TITLE: Individual Survival Equipment (Cold-Water Survival)

TECHNICAL RÉSUMÉ: The objective of this project is the development and evaluation of individual survival equipment. This effort will be primarily concerned with cold-water survival and the man overboard system.

PROJECT INTERFACES: Supported by 090100 and 090300.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
090401 Conduct Tests and Evaluation of Hypothermal Protect and Flotation Clothing	50	100	100			250
090402 Develop and Test Equipment Evolved		50	150	100		300
090403 Develop Systems, Procedures to Enhance Survivability			50	100	100	250
Total Funds	50	150	300	200	100	800

LEVEL: Tasks NEXT LEVEL ITEM: Individual Survival Equipment (Cold-Water Survival) PROJECT: 090400

090401 Conduct tests and evaluations of existing equipment for hypothermia, wearability, floatation, and ability to don and manipulate in the dark and in the water.

090402 Develop and test design innovations which meet survivability criteria and incorporate the best features of 090401

090403 Develop systems, procedures to improve the chances of survivability of the man overboard. The combined work jacket, floating, and thermal protective garment offers the most promising approach to solving this problem.

LEVEL: Project NEXT LEVEL ITEM: Crew/Passenger Safety Project Area ITEM NUMBER: 090500

TITLE: Retrieval Equipment

TECHNICAL RÉSUMÉ: The objective of this project is the development and evaluation of system components which will improve the retrieval phase of survival, and provide a means for responding to a man overboard on ships and structures not equipped with powered life-boats.

PROJECT INTERFACES: Supported by 090100 and 090300.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
090501 Evaluation of Existing Boats as Rescue Boats	75	100	100			275
090502 Evaluate Existing Davit Designs		75	25			100
090503 Develop and Test Inclined Plane Launch System	50	75	75			200
090504 Develop and Evaluate Retrieval Equipment		50	75	75	25	225
Total Funds	125	300	275	75	25	800

LEVEL: Tasks NEXT LEVEL ITEM: Retrieval Equipment PROJECT: 090500

090501 Conduct an evaluation of existing boats as rescue boats to provide the capability of retrieving individuals from the water in abandon ship operations, and to provide ready response to a man overboard.

090502 Evaluate the capability of existing davit designs for launching rescue boats.

090503 Develop and test inclined plane launching systems for rescue boats.

090504 Develop and evaluate retrieval/detection equipment. Detection equipment could include visual and audio devices as well as radar reflective caps. Floating florescent streamers and/or jackets should also be considered. Retrieval equipment should consider handling injured and personnel incapacitated by exposure to cold.

LEVEL: Project NEXT LEVEL ITEM: Crew/Passenger Safety Project Area ITEM NUMBER: 090600

TITLE: Underwater Rescue Vehicle

TECHNICAL RÉSUMÉ: The purpose of this project is to define the necessary operational and physical requirements for a simple underwater rescue vehicle and to define the availability and ready accessability to all underwater rescue vehicles meeting these standards.

PROJECT INTERFACES: Supported by use projections from 010100 and casualty information from 010200.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
090601 Survey Current State of the Art	50	60				110
090602 Define Physical Characteristics to Meet Requirements		50	100			150
090603 Develop Desired Specs			100	250		350
Total Funds	50	110	200	250		610

LEVEL: Tasks NEXT LEVEL ITEM: Underwater Rescue Vehicle PROJECT: 090600

090601 Survey current research submersible operating limits and vehicle characteristics to define necessary rescue capabilities.

090602 Define necessary physical and operational requirements (i.e., capacity, weight, etc.).

090603 Using available design/performance information from the Navy, submersible operators, and submersible manufacturers, develop desired specifications for a rescue vehicle. Perform tradeoff studies among capabilities and expected rescue missions to establish desired specifications. Identify areas of concern and recommended alternative courses of action or standardization in submersible design requirements.

LEVEL: Project NEXT LEVEL ITEM: Crew/Passenger Safety Project Area ITEM NUMBER: 090700

TITLE: Submersible Survivability Requirements and Standards

TECHNICAL RÉSUMÉ: This project is to develop survivability requirements and standards for submersibles to be compatible with the rescue vehicle capabilities developed in Project 090600. Based on the capabilities for an underwater rescue vehicle, develop emergency scenarios for credible accidents and determine vital characteristics of small submersibles to enhance rescue operations. Characteristics, such as duration of life support and power systems, communications and navigation, emergency marker buoys, signal flares, means for providing external air and power to stranded submersibles, capability to jettison ballast, and other characteristics.

PROJECT INTERFACES: Supported by 090600.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
090701 State of the Art Survey	40					40
090702 Determine Vital, Characteristics for Survival and Rescue		80	60			140
090703 Develop Standards for Small Submersibles			80	100	100	280
Total Funds	40	80	140	100	100	460

LEVEL: Tasks NEXT LEVEL ITEM: Submersible Survivability Requirements and Standards PROJECT: 090700

090701 Conduct a state-of-the-art survey of existing small submersibles and underwater work systems. Develop scenarios of likely casualties and conditions.

090702 Determine vital characteristics of submersibles to facilitate search and retrieval operations.

090703 Develop standards for small submersible design, fabrication, certification, test, and maintenance and inspection.

LEVEL: Project NEXT LEVEL ITEM: Crew/Passenger Safety Project Area ITEM NUMBER: 090800

TITLE: Personnel Vapor Protection

TECHNICAL RÉSUMÉ: The purpose of this project is to acquire data and information to calibrate and modify vapor dispersion model as a tool for assessing health hazards to crew members. Three tasks are included: (1) definition of personnel exposure conditions, (2) model calibration, and (3) hazard evaluations.

PROJECT INTERFACES: Supported by 010200, 020100, and 080300.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
090801 Develop Profiles of Crew Exposures to Hazardous Fumes	75					75
090802 Conduct shipboard and model Tests of Vapor Concentration		150	250	200	100	700
090803 Evaluate Hazards and Recommend Changes		75	100	100	100	375
Total Funds	75	225	350	300	200	1150

LEVEL: Task NEXT LEVEL ITEM: ITEM NUMBER: 090800

090801 Definition of Personnel Exposure Conditions

Define the situation and conditions which involve contact between crew members and hazardous cargo vapors (gaging, tank cleaning, etc.). Develop profile of crew/cargo vapor interaction and define data requirements to quantify exposure. Establish experimental procedures for gathering data.

090802 Model Calibration

Conduct shipboard data gathering. Monitor vapor concentration/exposure times to quantify exposure profile. Evaluate and revise vapor dispersion model as necessary. Integrate exposure profile into dispersion model to develop exposure model.

090803 Hazard Evaluation

Working with health hazard data and criteria generated in Project 020100, evaluate hazards of vapor exposure for various chemical products.

LEVEL: Project NEXT LEVEL ITEM: Crew/Passenger Safety Project Area ITEM NUMBER: 090900

TITLE: Industrial Diving Standards

TECHNICAL RÉSUMÉ: The objective of this project is to establish standards for industrial diving, including underwater inspection techniques, and standards for diving equipment and emergency procedures to be followed in the event of a diving accident.

PROJECT INTERFACES: None supporting.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
090901 Conduct Survey of Current Practice and Equipment	75	75				150
090902 Establish Standards for Diving Safety		100	100	100		300
090903 Establish Standards for Training and Qualification		50	100			150
090904 Evaluate Existing Underwater Inspection Equipment and Techniques	75	100	100	200	100	575
Total Funds	150	325	300	300	100	1175

LEVEL: Tasks NEXT LEVEL ITEM: Industrial Diving Standards PROJECT: 090900

090901 Conduct a survey of current diving practice, equipment, and decompression procedures. Determine the current state of the art in hard-hat (air and mixed gas), SCUBA and saturated diving techniques.

090902 Establish standards for diving safety utilizing both Navy and commercial practice. These standards include requirements for equipment.

090903 Establish standards for training,qualification, and requalification of divers.

090904 Evaluate existing underwater nondestructive testing and inspection equipment and procedures aimed at inspection of offshore structures, single point moars, and semisubmersible drilling platforms.

3.10 NORMAL MARINE OPERATION-INDUCED ENVIRONMENTAL DEGRADATION MINIMIZATION PROJECT AREA (100000)

3.10 NORMAL MARINE OPERATION-INDUCED ENVIRONMENTAL DEGRADATION MINIMIZATION PROJECT AREA (100000)

This project area deals specifically with environmental damage resulting from normal or routine operations performed by the various uses of the marine domain. In the past, heavy emphasis on, and the obvious nature of, oil pollution focused attention on discharges of polluting substances into the marine environment. This focus is now being expanded to include some of the more subtle, less visible, and largely not understood effects of activities in the marine domain. Among these are bank erosion, thermal pollution, waterway changes via dredging, and fishing industry-induced effects on the seabed. Specific problems in these areas are not yet identified if they do indeed exist; hence, there are no specific RDT&E project areas identified at this time. This project area is included for future inclusion of research in this area should the need be identified.

3.11 DISCHARGE DETECTION AND IDENTIFICATION PROJECT AREA (110000)

3.11 DISCHARGE DETECTION AND IDENTIFICATION PROJECT AREA (110000)

As indicated by the logic diagrams, hazards associated with discharges of oil, hazardous substances, or other pollutants into U. S. waters are controlled by two lines of defense. The first is discharge prevention and the second is discharge control in the event a discharge has occurred. Embodied within this RDT&E plan document are numerous projects dealing with discharge prevention in that they help to enhance the inherent safety of the vessels and structures operating in the marine domain. These projects support Coast Guard actions aimed at reducing accidental discharges of polluting substances. Once a discharge has occurred, quick and effective response actions are required to reduce the hazard impact of the discharge and initiate appropriate enforcement action. Research in support of this activity is contained in Project Area 120000 "Discharge Response". To effectively close the control loop, however, it is necessary to be able to sense the presence of a discharge, its nature and its source, and, further, to be able to do so in a reliable and timely way. This is the thrust of this program area.

3.11.1 Primary Anticipated Hazard

Discharges which occur incidental to a serious marine casualty are generally obvious. However, statistics indicate that the source of most of the pollution in U. S. waters is a large number of minor and less obvious pollution incidents, both accidental and intentional. While the law requires that such incidents be reported promptly, the fact is that compliance with this law is poor. If no means for enforcing compliance is at hand, then no control can be exerted over the most serious mode of polluting the marine environment.

3.11.2 Project Area Research Strategy

The direct, and only, course of controlling this hazard is to enhance the Coast Guard's and industry's capability to (1) detect discharges of oil, hazardous substances, and other polluting materials into U. S. waters; and (2) to identify such discharges in terms of type, quality, and source. Such capability will obviously enhance the effectiveness of spill response actions as a hazard mitigating option. Additionally, such a capability would foster the reporting of accidental discharges which are currently unreported. Furthermore, and perhaps most importantly, effective detection and identification capability would be a powerful deterrent to unlawful intentional discharges. Hence, in addition to its role as a part of discharge response enhancement, research in this area supports and supplants other discharge prevention actions by the Coast Guard.

Five projects are included in this project area. The first deals with completing on-going R&D in the development of oil discharge surveillance capabilities for both wide area (aerial techniques) and local (surface techniques) coverage. The second covers the development of similar techniques, both surface and aerial, for the surveillance of nonoil, hazardous material discharges. The third project is aimed at completing research in the identification of oil pollution sources through forensic analysis techniques and enhancing existing identification techniques via computerization for more timely and efficient analysis. The fourth project is to do the same thing for nonoil, hazardous material discharges. In the latter two projects, every effort is to be made to build upon the knowledge bases developed in the first two projects and on current experience. It is noteworthy that, because the projects addressed to nonoil discharge situations will be concerned with a large number and variety of toxic substances, it is difficult to bound these projects in terms of time. It is likely, in fact, that research activity in hazardous substance detection and identification will continue throughout the foreseeable future.

The last project deals with completion of on-going efforts in the control of ocean dumping to ensure compliance with applicable permits. The current surveillance approach utilizing Loran-C track recorders offers an appropriate level of control and the specific R&D is aimed at verification and project completion.

LEVEL: Project NEXT LEVEL ITEM: Discharge Detection and Identification Project Area ITEM NUMBER: 110100

TITLE: Oil Discharge Surveillance Systems Development

TECHNICAL RÉSUMÉ: The objective of this research is to complete the development of local and wide area surveillance systems for the detection of oil discharges in ports/waterways and the contiguous/prohibited zone. Three tasks are included: (1) development of detection cirteria, (2) completion of the aerial surveillance system, and (3) completion of the surface surveillance system.

PROJECT INTERFACES: Supported by hazard trend information from 010100 and material property information from 020100 and 020300.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
110105 Detection Criteria Development	150					150
110110 Aerial Surveillance System Development	1350	200	100			1650
110120 Surface Surveillance System Development	350	50				400
Total Funds	1850	250	100			2200

LEVEL: Tasks NEXT LEVEL ITEM: Oil Discharge Surveillance Systems Development PROJECT: 110100

110105. Detection Criteria Development

Examine existing water quality data in selected high spill risk areas. Supplement, as necessary, with tests to define "normal" background noise" beyond which discharge sensing capability must be effective. Establish the minimum discharge to be detected over this background level. By examining the normal background noise variations (e.g., changes induced by currents, storms, winds, etc.) determine likelihoof-of-detection sensitivity and the required detection parameters for detection at selected confidence levels. Develop a profile of detection probability versus discharge quantity and establish target effectiveness levels for detection.

110110. Aerial Surveillance System Development

Complete the development of an aerial sensor package for integration into MRS aircraft including a radar prototype, identification/classification prototype, film thickness measurement prototype, and system prototype. Perform necessary tests (laboratory and field) to evaluate the system and to establish expected operating effectiveness with respect to criteria established in 110105. Further adapt the developed system to conditions expected in the Arctic environment. Develop alternative schemes for sensor modification for adequate surveillance capability in that environment and develop these to the operational stage. Finally, for selected high risk oil discharge areas, establish system deployment patterns for alternative levels of coverage and detection probabilities. Perform trade-off studies and recommend appropriate deployment schemes.

110120. Surface Surveillance System Development

Complete the development of in situ/portable sensor package together with the necessary control and information display systems. Perform control tests and field tests to evaluate detection performance. Based on the results, revise and upgrade to required levels. Establish detection effectiveness levels expected in actual use with respect to the criteria established in 110105. Further adapt this developed system to conditions expected in the Arctic environment. Develop alternative schemes for sensor modification for adequate surveillance capability in that environment and develop these to the operational stage. Finally, for selected high risk oil discharge areas, establish system deployment patterns for alternative levels of coverage and detection probabilities. Perform trade-off studies and recommend appropriate deployment schemes.

LEVEL: Project NEXT LEVEL ITEM: Discharge Detection and Identification Project Area ITEM NUMBER: 110200

TITLE: Nonoil Discharge Surveillance System Development

TECHNICAL RÉSUMÉ: The objective of this research is to develop local and wide area surveillance systems for detecting discharges of nonoily hazardous materials in ports/waterways and contiguous zones. Three tasks are included: (1) development of detection criteria for a variety of materials, (2) development of sensor packages where feasible, and (3) development of a plan for surveillance deployment.

PROJECT INTERFACES: Supported by hazard trend and traffic information from 010100 and by materials property information from 020100 and 020300.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
110201 Development of Detection Criteria		100				100
110202 Development of Sensor Packages		200	700	1300	500	2700
110203 Develop Surveillance Deployment Plan					250	250
Total Funds		300	700	1300	750	3050

LEVEL: Tasks NEXT LEVEL ITEM: Nonoil Discharge Surveillance System Development PROJECT: 110200

110201. Development of Detection Criteria

Identify primary sensing parameters for selected, high-hazard-potential materials. Using and expanding background noise studies of 110105, determine background levels of pollution which influence sensitivity of detecting hazardous materials. Based on hazard ratings determined in Project 020100, determine minimum concentrations for detection. Determine sensitivity requirements and required detection parameters for selected confidence levels. Develop a profile of detection probability versus discharge quantity and establish target effectiveness level for detection. Explicitly delineate those hazardous materials for which detection capability is lacking and not within the state of the art.

110202. Development of Sensor Packages

Where detection is possible and feasible, develop required sensor capability for both aerial and surface surveillance systems. Every effort should be made to integrate and utilize the surveillance technology developed for oil discharges. Test and evaluate resulting sensors and establish the effectiveness levels expected in operation.

110203. Develop Surveillance Deployment Plan

For selected high risk discharge areas, using criteria developed in 110201 and operational effectiveness measures developed in 110202, establish sensor deployment patterns for alternative levels of coverage and discharge detection probabilities. Perform trade-off studies and recommend appropriate deployment schemes for selected high risk areas.

LEVEL: Project NEXT LEVEL ITEM: Discharge Detection and Identification Project Area ITEM NUMBER: 110300

TITLE: Development of Second Generation Oil Identification System

TECHNICAL RÉSUMÉ: The objective of the project is to develop a capability for quick and effective, near real-time oil identification and source matching for field use. Six tasks are included: (1) state-of-the-art assessment, (2) criteria development, (3) definition of analytic requirements, (4) development of analytic procedures, (5) definition of source data requirements, and (6) prototype system development.

PROJECT INTERFACES: Supported by 010100, 020100, and 020300.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
110301 State-of-the-Art Assessment	150					150
110302 Criteria Development	300					300
110303 Analytic Requirements	100	200				300
110304 Analytic Procedure	40	100	100			240
110305 Source Data Requirement		105	100			205
110306 Prototype System Development			300	500	100	900
Total Funds	590	405	500	500	100	2095

LEVEL: Tasks NEXT LEVEL ITEM: Development of Second Generation Oil Identification System ITEM NUMBER: 110300

110301. State-of-the-Art Assessment

Critically examine the Coast Guard's existing capabilities in forensic analysis of oil and oil products. Interact with field personnel to identify the precise problems with both the adequacy of identification techniques and the procedural requirements.

110302. Criteria Development

Examine the precision of current identification practices. Perform selected analyses to define variations in analytical results as influenced by sample variations and analytic procedures employed. Analyze several samples of oil from different sources and determine discrimination potential for various analytic techniques. Based on these results, define the criteria for identification sensitivity and descrimination.

110303. Definition of Analytic Resuirements

Based on the results of 110301 and 110302, determine the appropriate analytic technique to be employed. Consideration should be given to but not limited to areas such as gas and liquid chromatography, fluorescence spectrometry, trace element analysis, and infrared and mass spectroscopy.

110304. Analytic Procedures Development

In conjunction with 110303, develop analysis procedures for computer acquisition of data. All data should be acquired under computer control or from a few, simple analytic procedures for entry into the computer.

110305. On-Line Source Identification Techniques

Using sample variations examined in 110302, existing Coast Guard data from past analyses, and additional sample analyses as necessary; identifiy the data requirements for on-line source identification using matching or pattern recognition techniques.

110306. Prototype System Development

Specify necessary system characteristics, hardware, and software requirements to perform necessary functions of real-time, simultaneous data acquisition and analysis. Consideration should be given to computer capabilities which are available at field offices (for example, MSIS) to utilize existing terminals, networks, and perhaps computers. Develop prototype system and demonstrate its utility and identification capability.

LEVEL: Project NEXT LEVEL ITEM: Discharge Detection and Identification Project Area ITEM NUMBER: 110400

TITLE: Develop Nonoil Identification System

TECHNICAL RÉSUMÉ: The objective of this project is to extend the analytic capability developed in Project 110300 to the problem of identification of nonoil hazardous materials for early identification as required for response action as well as for source identification. Three tasks are included: (1) develop analytic protocol, (2) data requirements, and (3) identification system modification.

PROJECT INTERFACES: Supported by trend information from 010100 and materials information from 020100 and 020300.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
110401 Analytic Protocol	450	100	25	25	25	625
110402 Data Requirements	200	400	35	25	25	685
110403 System Modification		95	500	300	50	945
Total Funds	650	595	560	350	100	2255

LEVEL: Tasks NEXT LEVEL ITEM: Develop Nonoil Identification System PROJECT: 110400

110401. Develop Analytic Protocol

Develop the proper analytic protocol for identification of CHRIS listed chemicals. These should rely heavily on Fourier-transform infrared spectroscopy, using state-of-the-art gas chromotography and infrared techniques where possible, combined with inorganic analysis as needed. If necessary, two levels of identification, using different techniques, are permissible. The first, which should be quick and responsive to hastily collected samples, must identify the chemical or class of chemical as required to initiate appropriate response actions. (Close correlation interaction with projects in 120000 is required.) The second may employ advanced techniques as appropriate for source identification.

110402. Data Requirements

Analyze artificial spills of hazardous substances as required to establish variations due to material type, spill location, and source. Identify analytic techniques and data matching requirements for selected levels of accuracy and discrimination. Examine the use of reverse search techniques to take advantage of their insensitivity to samples contamination and effectiveness in identifying organic/inorganic compound components.

110403. Identification System Modification

Based on the above, develop necessary modifications to the identification system developed in 110300.

LEVEL: Project NEXT LEVEL ITEM: Discharge Detection and Identification Project Area ITEM NUMBER: 110500

TITLE: Ocean Dumping Surveillance Support

TECHNICAL RÉSUMÉ: The objective of this project is to provide necessary support to complete current efforts on the development of a LORAN-C track recorder for use in monitoring ocean dumping activities. Three tasks are included: (1) test and evaluation of track recorder, (2) evaluation of effectiveness as surveillance tool, and (3) recorder modification as required.

PROJECT INTERFACES: Supported by 010100, 110200, 110400, and 051000.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
110501 Test/Evaluation	25					25
110502 Effectiveness Measures	25					25
110503 Modifications		50				50
Total Funds	50	50				100

LEVEL: Tasks NEXT LEVEL ITEM: Ocean Dumping Surveillance Project ITEM NUMBER: 110500

110501. Test and Evaluation of Track Recorder

Upon receipt of LORAN-C track recorders, place one aboard a Coast Guard vessel and conduct trials to establish accuracy and repeatability measures of performance. Establish implementation procedures and monitoring requirements for vessels operating under ocean dumping permits.

110502. Evaluation of Effectiveness as Surveillance Tool

Establish mechanisms for a test period of visual observations and reporting by Coast Guard vessels and aircraft on an opportunity basis incidental to other operations. Examine need for special periodic visual tracking. Monitor recorder results for test period (say 6 months) and compare with visual observation results. Establish measure of effectiveness of recorders as surveillance tool.

110503. Recorder Modification as Required

Based on results of 110302, examine the need and opportunity for improvements in performance and recommend second generation surveillance tool if required.

3.12 DISCHARGE RESPONSE PROJECT AREA (120000)

3.12 DISCHARGE RESPONSE PROJECT AREA (120000)

This project area concerns research and development efforts supporting the Coast Guard's achieving the capability to respond effectively to discharges of hazardous substances into the marine domain. Based on the assumption that such discharges will occur in spite of the best efforts made to prevent them, the needed response capability consists of being able to

(1) Take effective actions to control the spread of discharged hazardous materials and/or ameliorate their effects by minimizing toxic or combustible hazards.

(2) Provide equipment and techniques for removing the discharge material.

(3) Provide equipment and techniques for disposing of the removed material.

These capabilities do not provide for a full return to the pristine environment--this is recognized to be infeasible--but they should be pegged at achieving a reasonable final state of cleanliness.* Further, they must be able to contend successfully with an enormous range of types of hazardous materials and must do this in operational conditions varying from tropical to Arctic climates, smooth to rough seas, and congested harbor to open-sea locations.

The research efforts supporting the further development of these response capabilities will be concerned with developing adequate knowledge of the discharge behavior of all the potentially spillable materials and the methods to be used in confining them and neutralizing their effects, developing a variety of recovery/disposal techniques suited to different operating conditions, and finding solutions to the logistics problems posed in deploying these response capabilities.

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* Criteria for what constitutes a "reasonable state of cleanliness" remain to be defined by EPA and other pertinent agencies of the Government. This research plan is designed to be responsive to such criteria when provided but able to go ahead and develop its own if they are not.

3.12.1 Background

A substantial amount of R&D work has been done on safe stowage and transfer of the many hazardous materials now being transported by ships or barges but, with the exception of petroleum products, comparatively little has been done on controlling, removing, and disposing of these materials when spilled. Further, the progress toward a satisfactory capability in this field with respect to petroleum spills has been limited to comparatively favorable operational conditions. The recent difficulties in controlling oil spills in winter storm conditions in the Atlantic testify to the inadequacy of present control/recovery capabilities when confronted by such conditions. With respect to the many nonoil hazardous materials that may have to be dealt with, some effort is represented by the data bank on material behavior factors made available through the CHRIS program and by the development of regional contingency plans in the United States. However, the adequacy of these measures was challenged by the slow responses to the chlorine barge accidents in the Ohio and Mississippi Rivers and, more recently, to the capsizing of an oleum-laden barge in Chesapeake Bay where the parties concerned with the casualty did not have the means or knowledge at hand to avert the disasters implicit in the event.

3.12.2 Project Area Research Strategy

The research needed to support the emplacement of greater response capability is divided into four project areas: (1) further development of techniques for oil discharge response including techniques for severe operating conditions; (2) a broad program to develop discharge response technology for spills of nonoil hazardous materials; (3) development of solutions to the logistics problems involved in deploying and maintaining adequate response capabilities; and (4) development of plans for training personnel and providing for their protection.

LEVEL: Project NEXT LEVEL ITEM: Discharge Response Project Area ITEM NUMBER: 120100

TITLE: Development of Techniques for Oily Discharge Response

TECHNICAL RÉSUMÉ: The objective of this project is to develop oily discharge response techniques for severe environment situations, building as much as possible on extrapolation of existing response technology. Also included in this program are tasks covering the further development of instrumentation and separation techniques involved in oily discharge response. Six separate tasks are identified as shown in the table below.

PROJECT INTERFACES: Supported by casualty trend information from 010102, release behavior information from 020300, and fire/explosion hazard control information from 080400, 080500, and 080600.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
120110 Arctic Response	1100	1500	1100	800	500	5000
120120 Fast Current Response	1450	1250	525	100	--	3325
120130 High Seas Response	1500	1000	1000	1000	--	4500
120140 Sorbent Support	500	300	100	--	--	900
120150 Instrument Support	50	50	50	50	50	250
120160 Multiagency	75	75	75	75	75	375
Total Funds	4675	4175	2850	2025	625	14,350

LEVEL: Tasks NEXT LEVEL ITEM: Development of Techniques for Oily Discharge Response PROJECT: 120100

120110. Arctic Response

Extrapolate the techniques of controlling, removing, and disposing of oil discharges to the Arctic environment to determine where modifications in method or equipment are needed in view of lower water/atmospheric temperatures, different water chemistry, and different climatological conditions in the Arctic. Systematically identify all the conditions in Arctic regions that would have a bearing on the elements of spill response capability. Identify alternative approaches to meeting the conditions and select the ones having the best net effectiveness analysis and through laboratory and/or on-site testing as appropriate.

120120. Fast Current Response

Develop techniques for controlling and removing oil spills in conditions where high currents dominate the dispersal pattern. Conduct analytical studies and critical experiments to establish methods for predicting speeds of dispersal, film thicknesses, and other factors of importance to the development of control techniques. Identify alternative approaches to control techniques and conduct laboratory and field tests to select the most effective ones. As a part of this task, conceive and develop more effective techniques and equipment for dynamic oil-water separation where thin films (resulting from fast-current dispersal) must be dealt with.

120130. High Seas Response

Continue the development of techniques and equipment for controlling oil spills in rough sea conditions (Force 4 and greater with commensurate wind velocities). Through studies of historical spills coupled with creative hazard analysis techniques, define a set of rough seas spill scenarios and establish tentative control criteria reflecting the degree of control needed and potentially feasible in the severe conditions postulated. Identify possible control techniques, building as much as possible on current techniques and equipment. Develop prototype equipment. Establish a full-scale proving ground at a coastal area where a variety of sea conditions are expected and conduct full-scale testing and development to qualify the techniques and equipment for the procurement and deployment stage.

120140. Sorbent Support

Continue the development of materials for use as sorbents in the spill control process for the purpose of enhancing the effectiveness and economics of control techniques and minimizing the cost of maintaining necessary stockpiles in suitable locations. This task should interface with 120120 and 120130 where use of sorbents appear to be viable options in those technique development tasks.

120150. <u>Instrument Support</u>

Identify and develop improved instrumentation and associated sensing equipment for monitoring the extent, progress, and physical structure of spills. Instrumentation should yield information on spill parameters that facilitate the making of correct on-site decisions as to the techniques and equipment to be utilized and reveal the stages of control and disposal as they are achieved. This task must interface closely with 120110 and 120120 so that the instrumentation developed will be an integral part of the technology of the control techniques developed.

120160. <u>Multiagency</u>

Maintain active liaison with other pertinent Government agencies as the above control techniques are developed so that appropriate dispositions for shared efforts and responsibilities in spill control operations can be made in advance.

LEVEL: Project NEXT LEVEL ITEM: Discharge Response Project Area ITEM NUMBER: 120200

TITLE: Development of Nonoil Discharge Response Technology

TECHNICAL RÉSUMÉ: The objective of this project is to develop techniques and procedures for appropriate response to nonoily hazardous material discharges, extending oily discharge response technology as applicable. An integrated program of analysis, laboratory testing, and field testing is envisioned. The project is subdivided into three tasks aligned with the elements of spill response.

PROJECT INTERFACES: Supported by 010100, 020300, 120100, and fire/explosion hazard control information from 080400, 080500, and 080600.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
120201 Discharge Control and Minimization	1000	1000	500			2500
120202 Discharge Amelioration	600	1100	1500	700		3900
120203 Hazardous Material Disposal Techniques				300	500	800
Total Funds	1600	2100	2000	1000	500	7200

LEVEL: Tasks NEXT LEVEL ITEM: Nonoil Response Techniques Project PROJECT: 120200

120201. Discharge Control and Minimization

Using applicable inputs from Project 020300, categorize hazardous materials (nonoil) by basic activity when spilled (e.g., vaporize, float, sink, mix). For floating discharges, examine the chemical properties and their impact on the utilization of techniques developed for oily discharge control. Conceptualize alternative techniques for confinement of all categories of discharge behavior including techniques for discharge minimization and treatment to facilitate confinement. Develop, by category and chemical if necessary, confinement, feasibility and recommended strategy. Develop and test selected promising candidates.

120202. Discharge Amelioration

For each category of discharge behavior defined in 120201, develop alternative techniques and strategies for minimizing the effects of a discharge. Utilize, as appropriate, oil spill removal technology, chemical neutralization techniques, dilution techniques, and other methods. Based on the results of this analysis and 120201, develop, for each chemical, a measure of amelioration potential and applicable requirements. This becomes a major input to planning response team logistics and safety (Projects 120300 and 120400), as well as the establishment of containment system and transfer system stringency levels for inherent safety.

120203. Hazardous Material Disposal Techniques

For those materials determined in 120202 as having a removal potential, identify the key disposal requirements giving due consideration to potential secondary hazards. Develop potential discharge/removal scenarios for selected high-risk areas. Identify necessary facilities/capabilities required to handle scenario situations. Identify locations where such capabilities exist with relation to expected high spill risk locations.

LEVEL: Project NEXT LEVEL ITEM: Spill Response Project Area ITEM NUMBER: 120300

TITLE: Spill Response Logistics Requirements

TECHNICAL RÉSUMÉ: The purpose of this project is to establish logistic requirements for effective responses to hazardous material spills and threats of spills in Arctic, temporate, and tropic regions. Included is the development of credible scenarios and the establishment of warehouse sites, mobilization and transportation of equipment and personnel to staging sites, and the delivery of and support of equipment and personnel to scenes of spills or impending spills of hazardous material.

PROJECT INTERFACES: Supported by information on response system technologies from Projects 120100 and 120200 and by spill models developed as a part of 020300.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
120301 Hazardous spill scenarios	50	100	150	100	50	450
120302 Spill response equipment pool siting	50	100	100	50		300
120303 Transport and mobilization of response forces		50	100	100		250
120304 Transport and support of response forces in hostile environments		50	100	100	50	300
Total Funds	100	300	450	350	100	1300

LEVEL: Tasks NEXT LEVEL ITEM: Spill Response Logistic Require- nebts Project PROJECT: 120300

120301. Hazardous Spill Scenarios

Develop credible scenarios of spills in various environments to establish the means for adequate responses to hazardous spills considering harmful effects and the behavior of hazardous spills developed in Project 020300 (Spill Modeling).

120302. Spill Response Equipment Pool Sites

From studies of marine activities, such as transport of hazardous materials, offshore oil and gas drilling, production, etc., marine traffic densities and casualty frequency projections establish sites for pools of response equipment and key personnel to permit quick responses to spills or impending spills. The reduction of the spread of hazardous materials is dependent on response time, and the strategic location of strike times can be critical in achieving adequate measures in combatting such hazards.

120303. Transport of Equipment and Personnel to Staging Sites

Utilizing the results of the above, establish the means for efficient mobilization of Coast Guard equipment and personnel along with private or commercial resources in an area for transportation to response staging areas.

120304. Transport of Response Forces to Spill Scenes

Utilizing the above, establish procedures and methods for transportation and support of response forces from the staging areas to the scenes of spills. Land, sea, and air modes should be available for rapid response and in some regions, such as the Arctic, low temperatures, ice, and snow will require special considerations. These include not only transport, but special means for housing and protection of personnel and equipment.

LEVEL: Project NEXT LEVEL ITEM: Spill Response Project Area ITEM NUMBER: 120400

TITLE: Personnel Training and Protection

TECHNICAL RÉSUMÉ: The purpose of this project is to establish procedures for responding to the discharge or impending spill of hazardous materials in an efficient and safe manner with respect to the personnel involved. The general approach involves setting criteria for safety and operational effectiveness and developing training programs and equipment schedules to facilitate meeting those criteria.

PROJECT INTERFACES: Supported by information on harmful effects of materials from 020100 and the output of modeling studies and experiments predicting spill behaviors in Project 020300 and the specifics of control methodologies from 120100, 120200, and 120300.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
120401 Development of Safety Criteria	200	100				300
120402 Protective Clothing and Life Support Equipment	250	225	200	25		700
120403 Training of Response Personnel				175	100	275
Total Funds	450	325	200	200	100	1275

LEVEL: Tasks NEXT LEVEL ITEM: Personnel Training and Protection Project PROJECT: 120400

120401. Development of Safety Criteria

With the results of harmful effects and spill behavior of various hazardous materials in Project 020300 in mind, develop safe and efficient procedures for deploying equipment and personnel at the scene of an accident. Equipment and procedures employed should be compatible with the harmful and reactive effects of the spilled materials. Detection and monitoring equipment and life support equipment should also be compatible to establish zones of danger. Also, emergency treatment of victims and strike team members stricken at the scene should be anticipated along with procedures for treatment.

120402. Protective Clothing and Life Support Equipment

Protective clothing and life support equipment compatible with the harmful effects of various hazardous substance should be developed. Also, extremes in climate should also be considered to protect personnel from the weather.

120403. Training of Response Personnel

Establish training methods for response and strike team personnel, ships crews, and others who may be exposed to harmful effects of hazardous materials. Personnel involved must be trained in safe and efficient response methods, the use of protective clothing, life support equipment, detection and identification sensor instruments, and emergency treatment of people exposed to hazardous materials.

LEVEL: Project NEXT LEVEL ITEM: Spill Response Project Area ITEM NUMBER: 120500

TITLE: Evaluation of Spill Response Capabilities

TECHNICAL RÉSUMÉ: The purpose of this project is to study discharge and spill scenarios involving hazardous materials, related spill behavior predictions, harmful factors, and evaluate the adequacy of contingency plans and procedures to deal with anticipated casualties. Criteria should be established for the adequacy of cleaning and removal of pollutants, and the impact of residues on the marine domain.

PROGRAM RELEVANCE:

PROJECT INTERFACES:

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
120501. Evaluate contingency plan	50	100	100	100		350
120502. Establish criteria for clean-up adequacy	75	100	100	100	100	475
120503. Determine impact of spill residue on marine domain			50	100	100	250
Total Funds	125	200	250	300	200	1075

LEVEL: Tasks NEXT LEVEL ITEM: Spill Response Capabilities Evaluation Project PROJECT: 120500

120501 Evaluate Contingency Plans

With the results of harmful effects and the behavior and spread of spilled materials studies and experiments outputs, evaluate regional contingency plans to determine the adequacy of those plans to deal with predicted casualties, and to update such plans for new materials and/or new data on the chronic or acute exposure limits of existing cargoes or materials handled in the marine domain.

120502 Establish Criteria for Clean-Up Adequacy

Conduct studies and experiments to establish criteria for the adequacy of clean-up. Clean-up equipment and procedures are at far from ideal efficiencies; therefore, considerable residue and damage to the environment will remain after any clean-up operation. Establish reasonable standards of cleanliness of the environment based on toxic and other harmful effects on marine life, human being, and property damage.

120503 Determine Impact of Spill Residue on Marine Domain

Utilizing data and results of harmful effects, spill behavior, inadequacy of clean-up procedures along with TLVs of various hazardous materials determine the impact of residual pollutants from clean-up and chronic effect of small spills on the marine domain in the way of ports, refineries, and deep water ports in particular.

3.13 HAZARDOUS MATERIAL TRANSFER SYSTEM FAILURE PREVENTION PROJECT AREA (130000)

3.13 HAZARDOUS MATERIAL TRANSFER SYSTEM FAILURE PREVENTION PROJECT AREA 130000

This project area addresses the hazards posed by the loss of control over hazardous materials during handling and transferring operations. Perhaps the driving force behind the identification of transfer failures as a problem area derives from the vessel/port transfer of a rapidly increasing population of hazardous chemicals and imminence of deepwater ports to handle VLCC's and ULCC's with their extremely large spill potential. However, hazards also attend the handling of materials produced by and in support of offshore industrial developments such as petroleum producing and preprocessing facilities and, possibly, facilities for extracting energy from thermal gradients in the sea.

3.13.1 Scope

This project area encompasses all interface equipment and related operating procedures required for the safe transfer of hazardous materials between transportation modes, between storage facilities, between storage facility and transportation mode, and between storage facility and consumption (e.g., as with fuels).

3.13.2 Primary Anticipated Hazards

As indicated in the logic diagram in Figure 16, transfer system failures can pose a number of hazards to people, property, and the marine environment. Specifically, hazards are posed to the general public and/or the marine environment by toxic or aesthetic pollution should these hazardous materials reach the water or be released into the air. Hazards are posed for the vessel or facility if spills of reactive materials (e.g., corrosive or cryogenic) weaken critical structural elements. Of course, the attendant hazards to all parties arising from the release of flammable/combustible materials is always present.

Recently enacted pollution prevention regulations for drip pans and liquid bulk cargo transfer inspection and monitoring provide control over part of the hazards. However, this project area extends beyond these into the basic causes of transfer releases and their control.

3.13.3 Project Area Research Strategy

The basic hazard control approach taken in this project area is accident prevention. Accordingly, the research strategy involves the systematic analyses of various generic types of hazardous material transfer operations conducted or expected to be conducted in the marine domain with the objective of isolating identifiable weak points of equipment or procedures and the development of appropriate strengthening actions. Four project areas are included at this time.

The first deals with liquid bulk terminal transfer facilities in a comprehensive systems analysis manner. The next two are basically problem definition studies related to dry bulk facilities and break-bulk facilities. While chemical hazards may or may not exist in these facilities, a corollary problem of material handling equipment failures and the hazards of dropped cranes/loads to vessel and shore personnel is included.

The last project is indicative of Coast Guard forward thinking regarding potential future problems associated with industrial exploitation of the oceans. This project consists of a preliminary hazard assessment of transfer systems utilized in subsea oil and gas production and petroleum preprocessing facilities on the continental shelf.

The first project can be considered an extension of current research on oil transfer systems being done by WDWP to support the Coast Guard's responsibilities with reference to the proposed Gulf Coast deepwater ports. These projects treat all facets of the oil transfer system with the objective of determining the best available technology to be employed, inspection and testing requirements to ensure that the technology-derived safety performance does not degrade, and to define safe operating limits within the safety constraints posed by the technologies employed.

These efforts are short lived, however; all are scheduled for completion prior to the practical time frame of the plan. Therefore, the first project is not intended to subsume these current efforts but, rather, to build on them for more general offshore port developments.

In addition to these projects, concern exists relative to various attempts to harness energy from the ocean. Of particular relevance is the Ocean Thermal Energy Conversion (OTEC) proposition being funded by ERDA. However, there is no identified research at this time for this subject. OTEC concepts developed have shown technical feasibility. Operational feasibility is questionable at this time due to the apparent economic disadvantages. The real activity to be performed here is one of monitoring developments to identify likelihood of application. This type of activity is accommodated in Project Area 010100.

LEVEL: Project NEXT LEVEL ITEM: Terminal Operations Spill Control Project Area ITEM NUMBER: 130100

TITLE: Liquid Bulk Conventional Terminals Analysis

TECHNICAL RÉSUMÉ: The objective of this project is to determine the optimum man/machine system for the cargo loading/unloading function and develop human performance and/or hardware requirements leading toward the optimum system. The research approach consists of (1) a state-of-the-art study to structure and define the problems involved, (2) a creative study of system alternatives to develop systems with better man/machine functional balance, (3) technical-economic assessments of feasibility of system alternatives, and (4) a study of performance requirements of personnel involved in the transfer process.

PROJECT INTERFACES: Supported by trend forecasts on industry volume levels and hazards from 010100, 010200, and 020100, and by spill response information from 120100 and 120200.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
130101 State-of-the-Art Study	50	25				75
130102 Definition of System Alternatives	25	75				100
130103 Technical/Economic Assessments		50	25			75
130104 Equipment/Personnel Requirements			50	50	50	150
Total Funds	75	150	75	50	50	400

LEVEL: Tasks **NEXT LEVEL ITEM:** Liquid Bulk Conventional Terminals Analysis **PROJECT:** 130100

130101 State-of-the-Art Analysis

Conduct a detailed survey of existing systems to develop generic categories (i.e., cargo types, pumping methods, etc.) for analysis. Using "on-line" results and inputs from Projects 010100, 020100 and 010200, identify trends and correlations of spills or near spills with these generic categories. For each category, define the workload split between hardware and human emphasizing critical operations such as control functions. Identify critical parameters influencing the occurrence of spills including human performance, equipment reliability, and equipment maintainability. Develop measures of safety factor as it now stands. Merge above into definition of effectiveness of systems including equipment, procedures, human capability.

130102 Definition of System Alternatives

Identify opportunities for achieving better balance among these three elements (improving safety factor) for both current and forecasted situations. Perform development and test work, including human factors testing to describe the nature of these improvements and verify improved effectiveness.

130103 Technical-Economic Assessments

Perform tradeoff analyses to determine sensitivity of effectiveness/technical/economic factors to variations in the system mix (e.g., more automation versus improved procedures).

130104 Equipment/Personnel Requirements

Develop required procedures for verification testing and in-service monitoring of performance for each alternative system mix. Establish personnel qualifications and means for examination and testing to confirm that requirements are met.

LEVEL: Project NEXT LEVEL ITEM: Terminal Bulk Discharge Analysis Project Area ITEM NUMBER: 130200

TITLE: Hazard Assessment of Dry Bulk Transfer Facilities

TECHNICAL RÉSUMÉ: The objective of this project is to define the particular problem posed during the transfer of dry bulk materials and to develop appropriate alternative control actions. Four tasks are included at this time: (1) dry bulk hazard identification, (2) transfer system technology assessment, (3) system safety studies to define hazards and accident sequences, and (4) countermeasure analysis to develop alternative Coast Guard control actions.

PROJECT INTERFACES: Supported by trend forecasts on industry volume levels and hazards from 010100, and by material hazards information from 020100

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
130201 Hazard Identification	25	25				50
130202 Technology Assessment		25	25			50
130203 System Safety Studies			40	60		100
130204 Countermeasure Analysis				50	25	75
Total Funds	25	50	65	110	25	285

LEVEL: Tasks **NEXT LEVEL ITEM:** Liquid and Bulk Conventional Terminal Analysis **PROJECT:** 130200

130201 Dry Bulk Identification

Conduct a systematic survey of dry bulk transportation. Using on-line results of Project 020100 (hazardous material characteristics) as available, identify materials which pose hazards if released into United States waters.

130202 Transfer System Technology Assessment

For selected classes of hazardous dry bulk materials, determine the state of the art of transfer systems and operating procedures for handling these materials.

130203 System Safety Studies

Using system safety analysis techniques, define existing and/or potential hazards, causal event sequences, and possible corrective actions.

130204 Countermeasure Analysis

Based on the results of 130203, develop possible regulatory countermeasures for alternative levels of control together with technical/economic, safety, and implementation impacts.

LEVEL: Project NEXT LEVEL ITEM: Terminal Bulk Discharge Analysis Project Area ITEM NUMBER: 130300

TITLE: Hazard Assessment of Break Bulk Transfer Facilities

TECHNICAL RÉSUMÉ: The objective of this project is to define particular failure modes and consequences for conventional break bulk transfer equipment as a basis for problem and countermeasure assessment. Three tasks are included at this time: (1) technology assessment to define the state of the art, (2) system safety studies to determine hazard and consequence severity, and (3) countermeasure analyses to determine alternative Coast Guard control actions and consequences.

PROJECT INTERFACES: Supported by trend forecasts on industry volume levels and hazards from 010100 and material hazard information from 020100.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
130301 Technology Assessment	40					40
130302 System Safety Studies		50	25			75
130303 Countermeasure Analyses		25	50			75
Total Funds	40	75	75			190

LEVEL: Tasks   NEXT LEVEL ITEM: Hazard Assessment of Break-Bulk Transfer Facilities   PROJECT: 130300

130301 Technology Assessment

Select three or four ports representing a cross section of break-bulk transfer operations (including at least one inland waterway terminal). Through on-site survey of facilities and operation, define categories of transfer equipment and their technological characteristics and operating procedures.

130302 System Safety Studies

Using casualty/accident/incident data available for these sites, together with system safety analysis techniques, define existing and/or potential failure modes, causal event chains, and alternative corrective actions.

130303 Countermeasure Analysis

Based on the severity of hazards and consequences defined in 130302, develop alternative possible Coast Guard regulatory countermeasures together with technical, economic, safety, and implementation impacts.

LEVEL: Project NEXT LEVEL ITEM: Terminal Bulk Discharge Analysis Project Area ITEM NUMBER: 130400

TITLE: Hazard Assessment of Offshore Oil/Gas Production Processing Facilities

TECHNICAL RÉSUMÉ: The objective of this project is to develop a complete hazard profile for offshore production and processing facilities as a basis for problem and countermeasure assessment. Three tasks are included at present: (1) state-of-the-art/technology forecast to define the system characteristics/operations, (2) review and extension as necessary of related safety analyses to develop hazard profile, and (3) countermeasure analyses to determine alternative Coast Guard control actions and consequences.

PROJECT INTERFACES: Supported by trend forecasts on marine-domain activities and hazards from 010100.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
130401 State-of-the-Art/Technology Forecast		40	30			70
130402 System Safety Review			50	50		100
130403 Countermeasure Analyses					50	50
Total Funds		40	80	50	50	220

LEVEL: Tasks NEXT LEVEL ITEM: Hazard Assessment Offshore Oil and Gas PROJECT: 130400

130401 State-of-the-Art Study/Technology Forecast

Through discussions with offshore oil/gas industry representatives and others associated with OCS oil/gas development, identify technologies, procedures, operating philosophies, and safety-related trade-offs employed or proposed for production systems (on or under the sea) and oi/gas preprocessing facilities.

130402 Safety Analyses Review

Review port studies (e.g., as done by API, NAS, NAE, CEQ) pertaining to safety of offshore production systems and facilities. Examine, as necessary and available, accident/incident histories of offshore oil/gas facilities. Extend safety analyses, as necessary, to develop complete hazard profile of offshore production and processing facilities. Identify corrective action opportunities.

130403 Countermeasure Analyses

Develop possible alternative Coast Guard countermeasures together with technical, economic, safety, and implementation impacts.

3.14 NONMARINE-CASUALTY-RELATED DISCHARGE PREVENTION PROJECT AREA (140000)

3.14 NONMARINE-CASUALTY-RELATED DISCHARGE PREVENTION PROJECT AREA 140000

Many of the problems developed in the logic diagrams and treated in other project areas deal directly with marine casualties as a primary source of hazardous material discharges with their attendant hazards to life, property, and the marine environment. However, marine casualties are not the sole source of such discharges. Within the marine domain, many polluting substances are routinely introduced into the environment as part of normal operations. Additionally, outside of the marine domain, but within the sphere of Coast Guard responsibility, land-based transportation facilities present increasingly significant discharge sources.

3.14.1 Background

Initial concerns in this area centered on the elimination of oil pollution resulting from ballast/deballast operations and tank cleaning operations. Recent activities by the Coast Guard and IMCO will greatly reduce these discharges through clean ballast requirements and tank cleaning slop separation and holding requirements. Fortunately, this course is equally valid for nonoil hazardous materials. Yet remaining to be resolved is the handling of noncargo wastewater and treatment thereof.

In the area of vented vapors, past Coast Guard research has concentrated on developing knowledge regarding the hazards associated with vented vapors. These have been concerned with developing vapor dispersion models and fire prevention/flame source performance and requirements. The actual data regarding vapor dispersion, personnel incidence to vapors, and the resulting hazards are not yet developed or conducted. Because of its direct relevance to personnel safety, this project is included in Project Area 090000.

Vapor recovery systems for transfer operations may reduce the amount of vented vapors and, hence, their hazards. Increased knowledge in this area is necessary to develop an appropriate regulatory stance.

The problem of discharges from transportation-related sources external to the marine domain (e.g., pipelines, trucks, tank cars) has not been fully defined or structured to develop an appropriate prevention posture. However, PIRS data indicate this to be a significant and growing portion of the pollution problem.

3.14.2 Project Area Research Strategy

Three projects are identified for administration in this project area. The first is a project aimed at developing and demonstrating wastewater pollution abatement techniques. The second project deals with a technological system and safety analysis of vapor recovery systems which may function in terminal operations. The third project deals with analyzing the character of discharges from nonmarine transportation sources to support the development of an appropriate Coast Guard prevention posture.

LEVEL: Project NEXT LEVEL ITEM: Non-Marine Casualty Related Discharge Prevention Project Area ITEM NUMBER: 140100

TITLE: Wastewater Pollution Abatement

TECHNICAL RÉSUMÉ: The purpose of this project is to advance Coast Guard knowledge of marine sanitation devices technology for regulatory support and certification of MSD's. The mechanism is to develop and demonstrate MSD's on Coast Guard vessels and extend the knowledge gained to the marine community. Three tasks are envisioned: (1) Coast Guard vessel applications, (2) generalize MSD knowledge, and (3) MSD regulatory support studies.

PROJECT INTERFACES: None supporting.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
140101 C.G. Vessel Applications	500	500	500			1500
140102 Generalize MSD Knowledge		500	500	200		1200
140103 MSD Reg. Support Studies				500	500	1000
Total Funds	500	1000	1000	700	500	3700

LEVEL: Task **NEXT LEVEL ITEM:** Wastewater Pollution Abatement **PROJECT:** 140100

140101 Coast Guard Vessel Applications

Complete development of flow-through wastewater management systems for Coast Guard vessels. Develop vessel waste incinerator for sewage and garbage. Develop and evaluate vessel wastewater management/re-use system for nonsewage wastewater.

140102 Generalize MSD Knowledge

Generalize the knowledge gained to cover non-Coast Guard vessel applicability. Identify scaling requirements and limitations for small boat applications. Conduct feasibility studies of new technologies to foster private development of MSD's. Demonstrate promising new technologies.

140103 MSD Regulatory Support Studies

Provide technical support and conduct short-term studies as required to support regulation development.

LEVEL: Project **NEXT LEVEL ITEM:** Non-Marine Casualty Related Discharge Prevention Project Area **ITEM NUMBER:** 140200

TITLE: Vapor Recovery Systems Analysis

TECHNICAL RÉSUMÉ: The purpose of this project is to develop a coherent information base regarding vapor recovery systems for use in tank vessel loading/unloading operations. Four tasks are considered: (1) state-of-the-art assessment of vapor recovery technology, (2) determine marine applicability (3) identify critical testing requirements, and (4) Identify qualification, testing/inspection requirements.

PROJECT INTERFACES: Supported by 010100, 010200, 020100, and 080300.

Task Designation	Program Year					Total Funds
	1	2	3	4	5	
140201 SOTA Vapor Recovery Technol		100				100
140202 Marine Appl. Vapor Recovery		50	100			150
140203 Identify Crit. Testing Req.			50	50		100
140204 Identify Qual/Inspect. Req.				100		100
Total Funds	--	150	150	150	--	450

LEVEL: Task **NEXT LEVEL ITEM:** Vapor Recovery System Analysis **PROJECT:** 140200

140201 State-of-the-Art Assessment of Vapor Recovery Technology

Drawing upon information (foreign and domestic) regarding existing and proposed vapor recovery systems and techniques, define the vapor recovery state of the art. Catalog detailed descriptions of technique, applications, operating history, operating constraints, and operating data.

140202 Determine Marine Applicability of Vapor Recovery Techniques

From 140201, define the parameters of operation for various classes of recovery techniques. Develop an operating profile of the load/unload function and marine factors to be considered in marine vapor recovery application. These will include, as a subset, those parameters which influence the operation of vapor recovery systems. Conduct limited systems safety studies to evaluate the potential fit of existing/proposed systems to marine applications. Identify deficiencies and potential solutions.

140203 Identify Critical Testing Requirements

Based on the results of 140202, define the critical performance requirements of marine vapor recovery techniques and testing requirements to fully validate performance applicability.

140204 Identify Qualification/Inspection Requirements

Develop compliance testing requirements and inspection procedures required for vapor recovery system implementation.

LEVEL: Project NEXT LEVEL ITEM: Non-Marine Casualty Related Discharge Prevention Project Area ITEM NUMBER: 140300

TITLE: NONMARINE TRANSPORTATION-RELATED DISCHARGE PROBLEM ANALYSIS

TECHNICAL RÉSUMÉ: The objective of this project is to structure the problem of discharges from nonmarine sources. Two tasks are included at this time: (1) data analysis and problem definition and (2) preliminary examination of prevention alternatives.

PROJECT INTERFACES: None supporting.

Task Designation	Program Year 1	2	3	4	5	Total Funds
140301 Data Anal & Problem Def.				50		50
140302 Prevention Altern. Anal.					50	50
Total Funds				50	50	100

LEVEL: Tasks NEXT LEVEL ITEM: Non-Marine Discharge Analysis PROJECT: 140300

140301. Data Analysis and Problem Definition

Examine existing discharge data available within the Coast Guard and other sources (EPA, state records, etc.). Develop profile of discharges together with causal factors to the extent possible. Determine trends in discharge volume/severity.

140302. Prevention Alternatives Analysis

For selected source types identified in 140100, examine existing discharge prevention controls including other Government regulations, industry-imposed standards, and state-imposed regulations. Examine the need for Coast Guard involvement and the alternative approaches available for such involvement. For each approach, identify the implementation factors (e.g., Coast Guard resource requirements, industry impact, etc.), together with expected return (e.g., using other Coast Guard programs as benchmarks).

4.0 MODIFYING THE RDT&E PLAN

4.0 MODIFYING THE RDT&E PLAN

The RDT&E plan presented in the foregoing was designed without constraint as to budget or externally imposed requirements for milestone accomplishments. As such, this plan is the starting point for a continuing process of modification and revision. To be of permanent use, the plan must be dynamic--able to respond to the realities of limited budgets and the inevitability of changing conditions in the technological environment and within the Coast Guard. This involves the art of programming; choosing which projects are to be funded; the timing or sequencing in which they are done; and the ways in which they must be modified in objective or time so the combination--the total program plan--represents the most effective overall response to the program's goals within whatever constraints may be imposed.

This section deals with the practice of the art of programming as it pertains to this RDT&E plan. It does not present any specific recommended plans, only guidelines on approach and suggested methodology with some examples demonstrating certain aspects of the methodology. The actual programming of this plan can only be done by the Coast Guard management organization. It is hoped that the approach and methodology discussed here will prove helpful.

The art of RDT&E programming is composed of two interrelated practices: evaluating projects and selecting projects. Project evaluation is discussed in the major subsection immediately following. Project selection is then taken up in the next subsection.

4.1 EVALUATING PROJECTS--ESTABLISHING PRIORITY MEASURES

The level of dollar support for any program of activity, such as the RDT&E plan for Marine Safety, must be expected to vary from time to time. The plan must be designed to be alterable to fit these variations by adding or subtracting content, as the case may be, in such a way that the overall effectiveness of the plan in addressing its top-level objectives is maximized. The most difficult problem in doing this, of course, is cutting down on content to fit a reduced budget. Decisions must be made on which projects to remove or defer; this introduces the unavoidable issue of evaluating projects with respect to some explicit criterion in order to determine relative priorities among them.

The evaluation of any project in the plan depends on several factors. The most important are

- Benefit--the degree to which an RDT&E item contributes to the solution of the RDT&E--susceptible part of the marine safety problem.
- Benefit-cost--the effectiveness with which an RDT&E item utilizes budget committed to it.
- Interdependency--the degree to which another item in the RDT&E plan is dependent.

Experience indicates it is neither practical nor theoretically correct to lay down a rule as to which of these should be used to determine the relative priority among a set of projects. There will always be other extraneous, often highly intangible, factors entering into real world decisions regarding budgeting. Most of these involve management considerations only perceivable to higher command levels and subject only to judgment calls. Planners/analysts cannot and should not attempt to take such factors into account. However, assembly of information on the items listed above can form a highly useful framework of "objective" priority factors within which final decisions can be made with greater confidence based on deeper insight into the effectiveness issues involved.

4.1.1 Formulating Benefit Measures

The definition of benefit given in the listing above merely described it qualitatively as a process--providing a contribution toward the solution of a problem; the definition didn't suggest or imply any way of measuring it. Such a means of measurement had to be developed in order to rank projects in order of relative benefit contributed. Since, in this endeavor, the issue was <u>relative</u> priority among the RDT&E projects in the context of a single ultimate goal of enhancing marine safety*, it wasn't necessary to work out a means of establishing absolute values for benefits; relative values referenced to some common baseline would suffice.

The problem dissection process which was the basis for the design of the plan provided a means of establishing a measure of relative benefits. This process involved first assigning some arbitrary numerical value--100 was the figure chosen--to the "total" marine safety problem represented by the top box, Event A, of the problem dissection diagram shown in Figures 2 and 3. Then this value was subdivided in accordance with the logic of the problem dissection diagram to arrive at numerical values for the primary problem areas and the subproblems within them. The magnitude or seriousness of each of these problems was considered directly proportional to the benefit of solving them. This applied, in turn, to the RDT&E-susceptible part of each of the problems identified by the process.

4.1.1.1 "The Total Problem Concept". The problem being addressed by the RDT&E plan was defined as all the RDT&E-susceptible aspects of the marine safety problem as it impacts the Coast Guard at any given time. This means all the problems associated with Coast Guard safety activities that are soluble through the provision of

- New data and/or information such as chemical properties of hazardous materials or the cost to society of increasing the stringency of a regulation on, say, maximum allowable speed of vessels in a waterway.

- New methods or procedures for performing mission tasks; examples would be designing and developing management information systems or developing methods for improving the efficiency of the vessel inspection process.

- Developed prototypes of new equipment that would either enhance marine safety directly (such as an improvement in the Loran navigation system) or would improve the effectiveness of Coast Guard activities (such as an improved hazardous material spill detection/identification system).

* See discussion of Goal Orientation, Section 2.1.2.

Providing results like these involves the expenditure of a large variety of different kinds of effort which aggregate to form the cost of the RDT&E program. This cost is not necessarily equivalent to the benefits resulting from doing the work. Rather, the benefits are aligned with the seriousness of the safety problems from the standpoint of the risks they pose. For example, suppose the type of marine casualties termed "collisions/rammings/groundings" could be significantly reduced by implementing a regulation on ship handling procedures based on a penetrating research analysis, not involving experimentation, in the human factors field. This would constitute a solution of a problem of major seriousness--risk--at a relatively modest cost. On the other hand, suppose a relatively small but still observable improvement in the effectiveness of harbor surveillance could be achieved only by bringing into play a new class of patrol craft designed around a novel type of power plant which has to be taken through a lengthy development process. In this case, the cost of overcoming a safety problem of only modest risk would be enormous.

Thus, the seriousness of a safety problem is to be thought of as the risk involved in allowing that problem to go unsolved. Risk, in this context, is equivalent to the expected loss associated with the problem. If accidents are implied, then the expected loss is the product of the estimated losses per accident and the frequency of occurrence. If the problem is failure to develop improved procedures, then the expected loss is the savings the improvement might have achieved. In any case, the loss should be broadly defined, from the Coast Guard's standpoint, as the total of detrimental effects (dollar losses plus intangibles such as human suffering, loss of well-being, reduction in Coast Guard stature, etc.).

In the procedures developed in connection with this RDT&E plan, these magnitudes were qualitatively assessed using judgments expressed in scalar values. Neither the levels of precision believed required, nor the time and resources available for generating the RDT&E plan, supported any attempts to evaluate benefits quantitatively on an absolute scale. The reference point for forming judgments on relative risks was the definition of the total marine safety problem as having a numercially convenient value of 100. It is often helpful for one visualizing the concept to think of this as being "100 percent of the marine safety problem as perceived by the Coast Guard".

4.1.1.2 Top-Level Benefits Evaluation. Figure 20 is a reproduction of Figure 2 showing a first-level evaluation of problem magnitude. The magnitude of the reference problem, Event A, was apportioned among the party-at-risk events in accordance with the study team's concept of their relative seriousness.

It is important to note that in making this apportionment, the study team was merely generating an example of the process of setting priorities. The intent of this example, as mentioned in the "Introduction" of this discussion, was to provide a strawman for the Coast Guard participants to rework. The evaluations made throughout this process can only be made effectively by the Coast Guard participants. They cannot be made by outsiders because outsiders are precluded from participation in the decision-making processes involved in setting RDT&E project priorities.

Carrying on with this as an example, then, the rationales used for the apportionments shown were as follows:

- The average value for each event, if each were judged equally serious would have been 16-2/3.
- The risk involved with cargo losses should be less than the average since protection of cargo has not been given major emphasis as a Coast Guard responsibility in the same way that protecting the marine environment has, for example. Further, by definition, human life or well-being is not involved with this party-at-risk.
- Vessel and facilities risks involve substantial loss potential from accidents and there is more pressure on the Coast Guard to protect these parties-at-risk.
- The other parties-at-risk involve hazards to people or the marine environment which involve the largest risks overall.

4.1.1.3 Primary Problem Area Benefits Evaluation. Once the events at the A level were weighted and values assigned, these values were then apportioned among the primary problem areas. Using the logic portrayed in Figure 3, the apportioned A-level values were deployed down through the trees. The procedure used in apportioning values to subevents was as follows: Where subevents were under an OR gate, the numerical value of the preceding upper

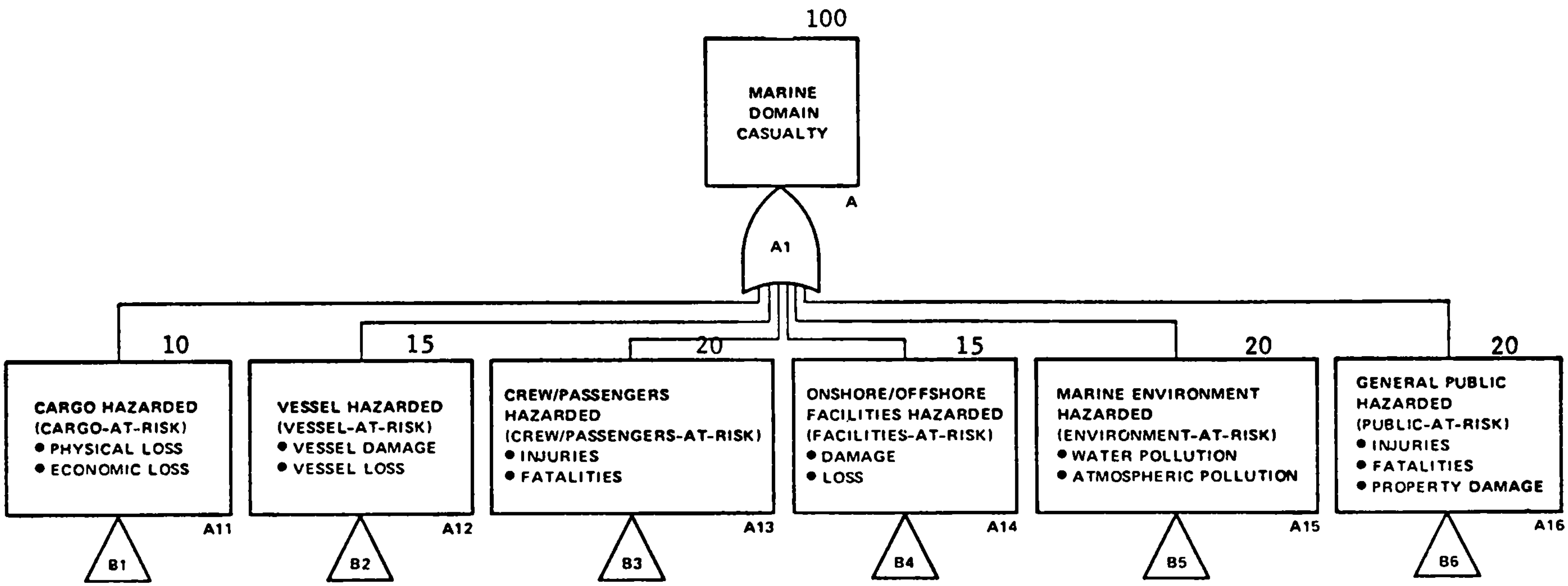


FIGURE 20. TOP LEVEL BENEFITS EVALUATION

event was divided in proportion to the estimated relative seriousness of the subevents. Where an AND gate was involved, each subevent was assigned the full value of the upper event. The reason for this is that all events funneling through an AND gate must occur to cause the upper event. Thus, the benefit of overcoming any one of the AND'ed subproblems is equal to the seriousness of the upper problem and gets the full value for that problem.

The selection of value splits at each junction was made subjectively with some reference to statistics on marine casualties, costs of accidents, and the like. These were leavened, however, with study team impressions of a variety of intangibles concerning trends in marine casualties and in the emergence of hazards associated with technological changes.

The benefit values accumulated for each of the primary problem areas in each branch are then summed together to give summary benefit values for each primary problem area. These summary benefit values are termed P_t's.

The deployment and apportioning of the strawman values selected by the project team is shown in Figure 20. The results of summing these values to form the P_t's is shown in Table 2.

In developing these values, the deployment and apportioning of benefit values was continued far enough down the branches so that values could be assigned to the primary problem areas wherever they appeared. Not all such appearances are shown in Figure 21. In some cases, the appearance of primary problem areas was repeated at lower levels; such are shown in Figures 4-6 and 8-12. All such values were taken into account in summing up the benefit values for each primary problem area.

4.1.1.4 Project Benefits Determination. The next step was to establish numerical values of the benefits attributed to each project; that is, an estimate of the contribution each project makes toward solving the primary problem area. Two factors are considered in making this estimate: an "access factor, f_a" and an "effectiveness factor, f_e".

The access factor is the fraction of the primary problem that the project could solve if it were completely successful. Estimating this fraction requires the evaluator to consider what part of the primary problem

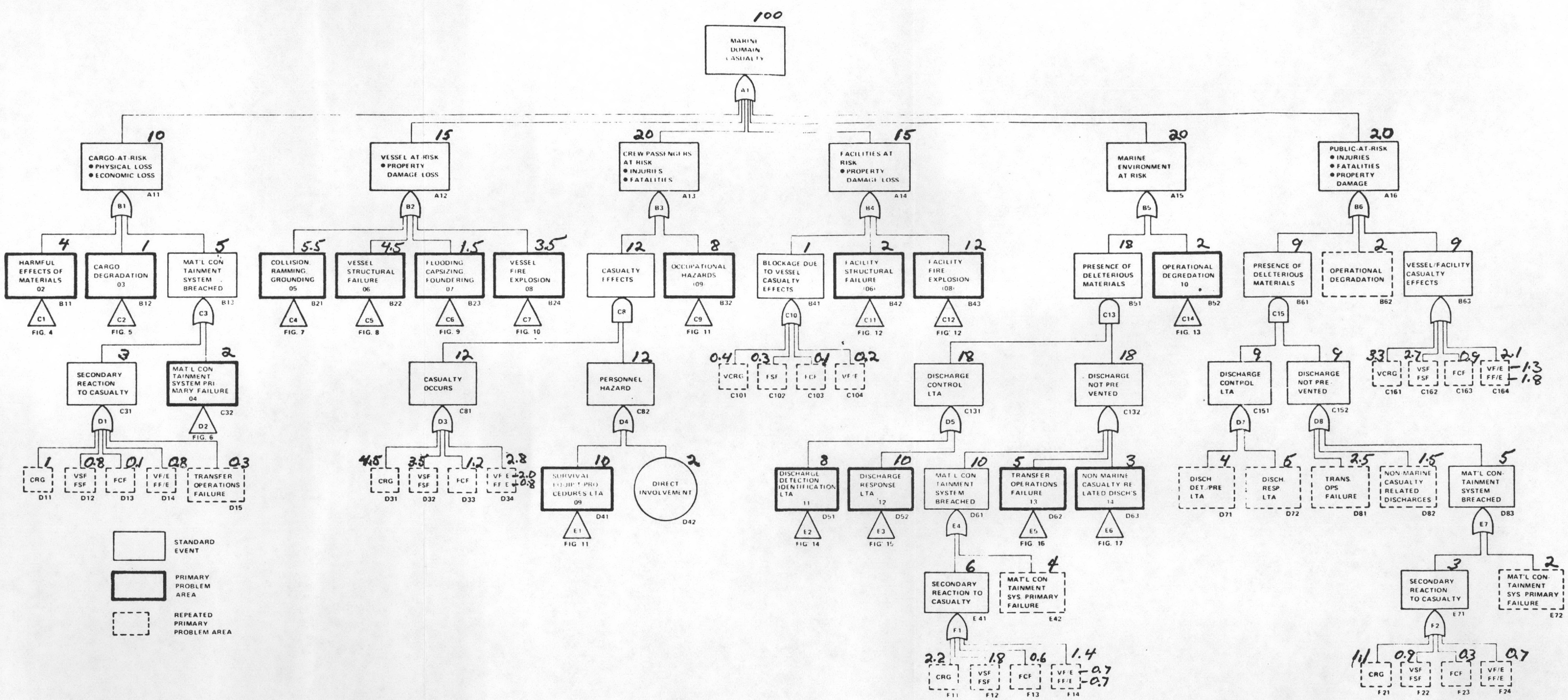


FIGURE 21. PRIMARY PROBLEM AREA LOGIC DIAGRAM

TABLE 2. PRIMARY PROBLEM AREA BENEFITS

	Primary Problem Area	Summary Benefit Value (P_t)
02	Harmful Effects of Materials	4.0
03	Cargo Degradation	1.0
04	Material Containment System Primary Failure	8.0
05	Collision/Ramming/Grounding	22.1
06	Vessel Structural Failure	12.3
	Facility Structural Failure	5.3
07	Flooding/Capsizing/Foundering	5.0
08	Vessel Fire/Explosion	9.2
	Facility Fire/Explosion	15.0
09	Personnel Survival	10.0
	Occupational Hazards	8.0
10	Operational Degradation of the Environment	2.0
11	Discharge Detection/Identification	12.0
12	Discharge Response	15.0
13	Transfer Operations Failures	7.5
14	Noncasualty-Related Discharges	4.5

is RDT&E-susceptible, that is, amenable to solution through RDT&E efforts as opposed to other ways of solving problems, such as increased manpower, deterrence, or large safety factors. It also requires that the evaluator consider what fraction of the RDT&E-susceptible part of the primary problem is addressed by the particular project under consideration. Finally, it requires that he consider the timing of implementing the solution--if it is near term the full value of benefit would be used but if the beginning of receipt of benefits is far in the future then appropriate discounting would be applied. For example, if a project were intended to reduce the incidence of human error as a cause of collisions/rammings/groundings, the evaluator might reason that

- The RDT&E-susceptible part of this problem is very large--there is no way that noncreative efforts, such as increased manpower or facilities, could greatly affect the problem.

- Furthermore, the incidence of these events is almost all ascribed to human behavior or capability problems and very little to hardware failures of different kinds.

- Finally, benefits of reduced collisions incidence would begin relatively soon after implementation of the effort.
- Based on these ideas, the evaluator might estimate a value of 0.9 for each aspect without any time discounting; this would yield a value of 0.8 for the project's f_a.

It should be noted that the f_a's for the projects falling in a particular primary problem area do not have to add up to one. In most instances, they will, and should, add up to substantially more than one. This results logically from the circumstance that the projects in a project area are not mutually exclusive as to the part of the primary problem they may be able to solve. Overlaps among them naturally exist--in some cases, in fact, there is deliberate intent to launch parallel efforts to solve the problems. Thus, no rules for setting the f_a values exist except the evaluator's judgment on RDT&E-susceptibility and the scope of the project's objective.

The effectiveness factor is an estimate of the likelihood that the project will be successful in meeting its avowed objective. Thus, the factor expresses simultaneously the evaluator's estimate of the technology gap that must be filled and the likely technical success of the project as proposed and funded in filling that gap. In effect, it answers the question of the form, "how much 'good' will this project do in reducing human error in ship handling?".

For example, in the above collision/ramming/grounding case, which yielded a high f_a, the evaluator could justifiably reason that the complexity of the problem and the results of past efforts in human performance improvement efforts necessarily preclude a high expectation of success. Hence, his judgment of f_e might be quite low, say for example 0.1-0.2.

The evaluation of the benefit value ascribed to a project may be described mathematically as follows:

$$N_b = P_t f_a f_e$$

where N_b = benefit number

P_t = primary problem area summary benefit value

f_a = access factor

f_e = effectiveness factor.

Using this relationship, the study team's calculation of N_b for Project 120100 "Development of Techniques for Oily Discharge Response" was as follows:

P_t = 15 - summed from Figure 20 and shown in Table 2

f_a = 0.4 - RDT&E-susceptibility very high, project aimed at about half the primary problem

f_e = 0.9 - technology gap large and likelihood of technical success is high.

Thus, $N_b = 15 \cdot 0.4 \cdot 0.9 = 5.4$.

This ranks as a relatively high benefit level in the set of projects evaluated as an exercise by the study team. This high ranking is consistent with the importance that pollution control activities have assumed in the Coast Guard and in other Government agencies. This example evaluation thus passes the test of plausibility; it is important to apply this test when evaluating projects with this methodology. There is much subjective content in the values assigned to the factors and it is, therefore, both legitimate and desirable to continually challenge the result of an evaluation. If it fails, the analyst should reexamine the assumptions or opinions underlying it. Under such a reexamination, flaws may be discovered which change the evaluation to one more believable or, conversely, it may be discovered that the evaluation, though surprising at first, is in fact rational and correct. This iterative process of making sure that project evaluations are plausible is an integral part of the methodology being discussed here.

4.1.1.5 Project Benefit-Cost Determination. The benefit-cost ratio, N_{b-c}, is formed by dividing a project's N_b by a project-related cost expressed in \$ millions. For example, the 5-year program cost estimated for Project 120100 is \$14.3 million so N_{b-c} is 5.4/14.3 = 0.38. This calculation states that Project 120100 is expected to produce 0.38 units of benefit (as defined in the previous section) per million dollars of research funds expended on it.

Recognizing that the above calculation involves a cost stream running over a 5-year period, one can greatly refine such calculations by using the present value of the cost stream rather than its future value as was done above. Assuming a discount rate of 10 percent, the present value of the 5-year estimated funding of Project 120100 is \$11.6 million giving a value of 0.46. Where projects are lengthy, this procedure gives a more accurate portrayal of the investment issues involved and should be routinely employed.*

The quantity N_{b-c}, then, is an evaluation measure having to do with how effective an expenditure related to a project is expected to be. It is of concern to those parties having a financial involvement in the conduct of the project or in the effects of the project when its results are implemented and who wish to see the money well spent. These include the following:

- The financial and technical management structure in the Coast Guard that makes the decisions about investing R&D funds in the project.
- Procurement agencies of the Coast Guard and other Government agencies who will make the decisions about the investments (capital and operating funds) required in implementing the results of the work.
- The marine industry which might experience new costs in connection with implementing the results of the work.
- Consumer groups who might have to absorb commodity price increases.
- The general public which absorbs all the costs listed above.

To the extent that the cost streams pertinent to each of the above interested parties can be estimated, the N_{b-c} of concern to each can be computed. Thus, projects can be evaluated in several different ways depending on which party's viewpoint is of concern. Each such evaluation would be "correct" as far as it goes. The question of which should be used in selecting projects for this plan depends completely on the policies governing fund allocation within the Coast Guard. It is noteworthy that the implementation costs will, in the majority of cases, be significantly larger than the R&D costs but the amplification factor is far from constant. To avoid distorted portrayals of how effectively Coast Guard funding is being spent, it seems prudent to include at least the implementation costs as well as the R&D costs in making benefit-cost evaluations regarding RDT&E projects.

*Those unfamiliar with the concept of the time value of money and the practice of discounting future cash flows can find discussions of the routine procedure used in this calculation in any standard textbook on engineering economics.

4.1.1.6 Evaluating Below the Project Level. As pointed out in Section 2.3.1, the plan structure is designed so that only projects are subject to independent evaluation as to their contribution to solving the marine safety problem. Tasks are regarded as being integral parts of projects not subject to independent evaluation.

However, as a practical matter, the administration of the plan will mostly be at or below the task level of aggregation; projects are too large and complex to be handled as single entities. This means that the judgments made on a year-to-year basis as to what should be included in the plan will be concerned with tasks. This raises the question; how should the prioritization evaluations be applied since they theoretically apply only to projects?

The answer can be reasoned out on the basis of the concept that tasks are integral parts of projects. Each should rank at the same level as the project of which it is an integral part. Thus, any task would be assigned the same N_b and N_{b-c} as its parent project.

4.1.2 Considering Project Interdependency Effects

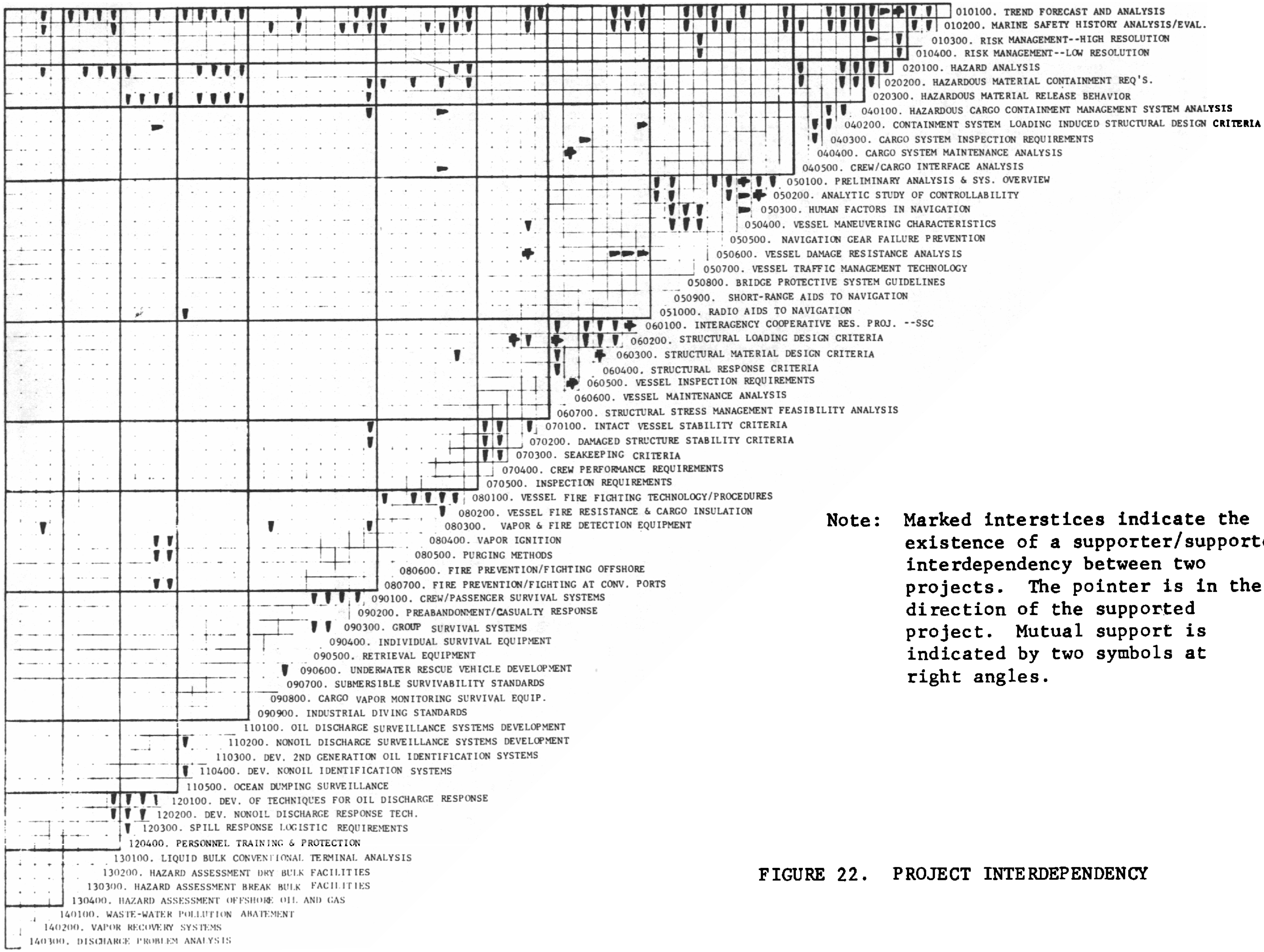
Although designed to seek independent objectives, the projects in the plan have a substantial amount of cross talk, that is, exchange of data and information of mutual usefulness in the pursuit of their independent objectives. In fact, as noted on the project work sheets in Section 3, supporting/supported relationships have been defined for almost every project in the plan. This is an important means of reducing duplication of effort and promoting efficiency within the plan's structure.

However, this interlocks the projects in the plan and markedly complicates the job of project evaluation. This is because each project must be thought of as providing support to one or more other projects, as well as solving the safety subproblem with which it is aligned. If a supporter project is assigned a low evaluation and removed from the plan, its inputs to the supported project disappear. If the supported project has a high evaluation, then some mechanism should exist in the evaluation methodology for rationalizing the retention of supporter's valuable inputs. As will be discussed below, the mechanism the study team considered most appropriate in modifying this plan is to track the effect on the supported project's evaluation of the supporter's removal or alteration and then decide on the utility of dropping the supporter by examining the value of the resultant, complete plan.

4.1.2.1 Nature of Project Interdependency. Interdependency exists when one project, as a by-product of pursuing its own objective, can provide another project with data, prototype equipment, or some other service that directly aids the receiving project in progressing toward its objective. The supporter's input can run the range from vital importance through mere helpfulness to coordinative. In the last case, the nature of the interaction is that the two projects need to adopt common standards, procedures, or techniques with respect to some operation such as manpower training or materiel inspection. It is difficult, if not impossible, to generalize on how to judge the intensity of an interaction between two projects; each pairing has to be examined as a unique situation.

Figure 22 depicts the interactions thought to exist in the RDT&E plan as presently designed. The symbology used is explained in the note on the figure. The symbology does not indicate the strength of a relationship, only that one exists. The interdependencies shown on the figure are also cited on the project worksheets except that the worksheet entries call out only the supporting projects in each case. Also, note that more detailed information on the kind of support involved is contained in the task description sheets following each project worksheet.

There are a few instances, as can be seen in Figure 21, of mutual support between projects. This indicates separate support transactions between the projects, not coordination. Coordination relationships indicate the presence of working commonalities between projects (i.e., 040300 and 060500 should coordinate their efforts because both are devoted to developing vessel inspection methods. In addition, 060500 supports 040300.). Thus, coordinated projects do not necessarily have supportive interdependencies; such projects can be evaluated separately. Coordination relationships



Note: Marked interstices indicate the existence of a supporter/supported interdependency between two projects. The pointer is in the direction of the supported project. Mutual support is indicated by two symbols at right angles.

FIGURE 22. PROJECT INTERDEPENDENCY

are not indicated on Figure 21, but they are called out in separate notations on the project worksheets.

The usefulness of a display like Figure 21 is that, in evaluating a project, one can quickly find out which projects it supports and, thus, which projects might be affected if the project under consideration is to be modified some way or even removed from the plan.

4.1.2.2 Effects of Interdependency on Project Evaluations. If a supporter is removed from the plan in order to reduce its cost, then the supported project's evaluation factor values will change. This is because the supported project's scope must be redefined to account for the loss of the supporter's input.

The change will not affect the supported project's P_t; this value is determined by the top-down distribution of benefit described in Section 4.1.1.3. It is likely to affect the f_a and f_e factors to some extent and will probably affect the cost substantially. The amounts of these effects depend entirely on how the supported project is redefined. If the part of the supporter that produced the input is incorporated fully into the supported project, then nearly all the change will be reflected in a project cost increase (which may have only a modest impact on the situation if projects are being evaluated on a total cost basis since the cost involved here would be the R&D component only). On the other hand, the decision might be made to run the supported project without the input involved. This usually involves reducing f_e since the project would be less likely to be technically successful without the needed input. Of course, if the input is highly critical, f_e passes to zero eliminating the supported project from the plan along with the supporter. Another option is to eliminate that part of the supported project's objective which was dependent on the supporter's input. This scales down the amount of the subproblem the project is intended to solve which would be reflected in a reduction of the value of f_a.

In this way, the impacts of modifying the RDT&E Plan by removing or stretching supporter projects can be tracked realistically and with some degree of objectivity.

4.2 SELECTING PROJECTS--DESIGNING THE MODIFIED RDT&E PLAN

The establishment of benefit and benefit-cost values for projects, as described in the previous subsection, does not obviate the need for research management's making complex, judgmental decisions regarding the selection of projects to be initiated/continued within a given funding/ timing constraint. What these evaluations provide is information pertinent to the process. The selection process itself remains as a separate and deliberate action. It is the most difficult aspect of program development and management because of the attitude of compromise and negotiation which must be brought to bear in defining a limited scope program satisfactory to all interest parties. The following subsections deal with two program design circumstances: modifying the plan to (1) meet budget constraints and (2) respond to changes in the technological environment.

4.2.1 Meeting Budget Constraints

The tools available for manipulating projects into a budget-constrained program are

(1) Reduce project scope and, hence, cost
(2) Increase project duration and, hence, cost/unit time
(3) Delete projects and, hence, program costs
(4) Delay projects and, hence, program cost/unit time.

Any or all of these may be invoked depending on the selection criteria employed. It is emphasized that project selection criteria are not the same as project evaluation criteria (although these should have some dimensional similarities). For example, an industrial company may evaluate projects on the basis of expected rate of return on R&D investment (one measure of benefit). One of the selection criteria may be to maximize total return for a given total R&D expenditure and individual projects would be selected accordingly. If ten projects are selected, they would probably not be the top ten on the priority list. (The top one, for example, may simply not be affordable.) Invariably, industry uses numerous other selection criteria, many of which do not bear on financial aspects at all. In some instances, selection criteria have been formalized and programmed into intricate computer programs to aid the decision-maker, but the final decisions are still largely management judgments.

Irrespective of the degree of rigor imposed, the Coast Guard must establish a set of selection criteria or at least guidelines. The study team cannot undertake to do this. It can only point out some of the options or considerations which are pertinent. This is done in the following sections. These options are not all inclusive nor are they necessarily recommended. They are intended solely to illustrate a range of options available.

4.2.1.1 Truncation on the Basis of Priority Measures. Using this philosophy, projects would be selected in order of their priority (giving due consideration to linkages to other projects) until the available funding is exhausted. This requires projection of funding expectations over time because an estimated future year cost for a given project may preclude its initial selection. A variation of this theme would be to select projects on the basis of priority and phase their start-up and completion times to more closely match annual expected funding levels.

4.2.1.2 Maximize Program Benefits. For a given funding level, one would select the set of fundable projects giving the highest total expected benefit (sum of individual benefit numbers). The selection process would generally go from highest to lowest on the priority scale skipping, as necessary, due to funding constraints. It is probable that more than one set of projects would be possible, requiring other criteria to be employed (for example, public pressure or urgency).

4.2.1.3 Perform Work on All Projects. This selection scheme involves numerous alternative implementation actions. Once the decision has been made that all projects are important and should be conducted, the management tools available are reduced to stretching time and/or reducing scope. To assess the total program effectiveness, each project would have to be reevaluated to assess the sensitivity of benefits to time delays and/or reduced funding levels.

4.2.1.4 Budget Limits by Division. In this philosophy, a minimum R&D budget would be established for each Office, Division, or Branch. Specific R&D projects of interest to that unit would then be selected (using other criteria such as those listed above) until the minimum funding was reached. Other projects would then be selected on the basis of priority (or other criteria as above) until the total R&D budget was exhausted.

4.2.1.5 Budget Limits by Primary Problem Area. This philosophy follows the previous one except that the decision is to have some minimum activity on-going in each of the primary problem areas. Projects within each problem area would be selected on the basis of priority or other criteria until this minimum funding level is exhausted. Other projects would then be selected on the basis of overall priority until the total budget is exhausted.

* * * * * * * * *

These examples are given to illustrate the project selection processes and criteria in support thereof. Establishing the particular methodology for use by the Coast Guard is a Coast Guard function and within the domain of the R&D Council. The specific procedures should be formalized only to the extent necessary to foster consistency of decision-making and to provide an accurate record of the decision process. It cannot be over emphasized, however, that in the final analysis, compromising judgments must be applied. Establishing any system for selection cannot negate this need.

4.2.2 Responding to Changes in the Technological Environment

The RDT&E Plan will frequently have to be modified to respond to changing conditions in the technological environment of the marine domain and also to changing conditions within the Coast Guard. Marine safety problems can lose their intensity or be set aside for various reasons, thus making the RDT&E effort related to them unnecessary. For example, changes in the world energy economy can be conceived that would lessen the need for establishing deep water offshore ports for the United States, or the development of novel vessel types such as hydrofoils might encounter a market failure. In either case, any research supporting the development of regulations packages and procedures relative to the two developments would become unnecessary. Further, research efforts that are perfectly well justified from a need standpoint might still encounter intractable technical difficulty so they should be stopped and resources committed to them directed elsewhere. Conversely, new problems will certainly emerge with the passage of time making it necessary to start new research endeavors directed to solving them.

4.2.2.1 Deleting Content. With regard to stopping a project and removing it from the RDT&E Plan, no particular difficulties are offered by the plan's formal structure or administrative setup--the task is simply to halt the effort giving due consideration to interdependency as previously discussed. The basic problem confronting the planner is arriving at a firm decision that the work should be stopped. Resistance to this once a project has been put in motion and gained a degree of momentum can be formidable. Overcoming this resistance and excising work that has lost its significance is one of the planner's highest duties.

There are three circumstances that individually or in combination can justify stopping a project: (1) its goal may actually be satisfied, (2) the need for its intended results may have disappeared, or (3) it may have encountered a severe technical problem such that its chances for success have become unacceptably low. A full treatment of these would be lengthy for the subjects are complex and require the exercise of judgments of the most difficult kind. Brief descriptions of some of the guidelines are given in the following paragraphs.

With respect to goal satisfaction, in the case of projects having the goal of producing an item of hardware or some other tangible thing, completion is not particularly difficult to determine. Only a small part of the RDT&E plan is concerned with hardware development, however. A substantial part consists of "continuing" projects such as the ones having to do with researching the properties of hazardous materials pertinent to containing them safely in vessels and facilities. Such projects do not have a discrete start and stop life cycle. Rather, they deal with a succession of tasks that are generically similar and which will continue to arise indefinitely. Decisions about stopping such projects likely will not be needed but, on occasion, an explicit decision will be needed that enough has been done on one of the tasks so that attention should be turned to the next one.

The projects that cause the most difficulty in deciding when goals have been achieved are those dealing with abstract or methodological subjects. Examples of this are the technological forecasting or the risk assessment methodology projects in the 01 group of the RDT&E plan. Only by explicit testing of the body of knowledge and procedures such projects accumulate as they proceed can it be determined which goals have been achieved. Two time-tested methods can be used to do this.

- Periodic progress reviews conducted by a third-party group with suitable expertise and with knowledge of what the project was trying to accomplish.
- Actual or simulated use of project results in the manner intended when the project effort was started.

Applying these means of testing the accomplishments of projects would be one of the functions of a Research and Development Council established within the Coast Guard to administer and direct the integrated plan of RDT&E effort supporting the W and M Offices.

With respect to disappearance of need, as noted above, changes can occur in the marine domain that obviate the need for certain parts of the RDT&E support plan. Detection of this is closely related to the actions suggested in the previous paragraph. Checking a project to see if its goals have been satisfied will, in most cases, raise the question of the current validity of the goals themselves. A more comprehensive approach to this question is embodied in one of the functions of the 01 series of projects, namely, to review and suggest revisions for the plan annually. The recommended procedure for this is to reexamine the whole structure of the plan deductively and reconfirm the validity of the goals through the problem dissection process.

With respect to technical failure, the most difficult technical management decision to make is that a project has encountered an intractable one. There are two reasons for this difficulty. First, it is logically necessary to show, in defending such a decision, that all possible avenues to a solution have been tried and won't work; in this sense, defending the negative position requires the most creativity of all. Second, almost inevitably, an adversary process must be carried out between the proponents and opponents of the particular project. It is almost irresistably tempting for proponents to put together rationales showing that a little more work will overcome the basic technical problem, especially when the project has imperceptibly become the hobby of powerful proponents and has been institutionalized within the organization.

Experienced practitioners of R&D administration consider the best remedy to these problems is applying the critical review process as stringently as possible. This should be done by an independent body, cross-linked with respect to the adversary groups in the organization (again, the R&D Council concept appears to be a sound way to establish such a group) and well qualified with respect to the technology involved. It must always be recognized that a finding of technical infeasibility is a judgment call--its credibility depends on the qualifications and stature in the field of the individuals making the judgments. Thus, it would be well for an R&D Council to avail itself of outside expertise in connection with doing critical reviews of projects.

An important aspect of this general question of technical infeasibility is applying the art of finding unplanned useful results in failed projects. More often than not a project can miss its intended ends by a wide margin but accomplish something even more valuable in the process. This can become the basis for redirecting rather than stopping a project. However, when this is done, it should be in the context of a top-down rationalization of the new objective within the logical structure of problems and needs framing the RDT&E plan.

4.2.2.2 Adding Content. The decision to add new work is not nearly as difficult to make as is the one to excise work already going on. Needs for new work tend to make themselves felt in a variety of ways, the most authoritative of which is accidents occurring in the marine domain. It is more difficult to identify needs for work in advance of such motivating accidents, but if the forward-looking projects of the 01 series are carried out, this can still be done in a practical and beneficial way. Thus, the validity and usefulness of doing new work--and much of the identification of needed new work--should come as a result of carrying out an orderly, annual RDT&E plan update process. Logical procedures reside in both the intellectual (premises, goals, and problem dissection) and mechanical (levels and numbering system accountability) structure of the RDT&E plan to support expanding it.