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LEVEL II

A STUDY OF USCG SURVEILLANCE REQUIREMENTS OVER THE NEXT 25 YEARS AND DEVELOPMENT OF A SURVEILLANCE R&D PROGRAM

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Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
United States Coast Guard
Office of Research and Development
Washington, D.C. 20590

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16. Abstract

The objectives of this study were to provide a multimission assessment of possible Coast Guard surveillance requirements over the next 25 years in 5-year increments; and to develop a Coast Guard surveillance R&D program. The recommended program was to consider likely future demands on USCG surveillance capabilities and develop a time-phased program which would allow the Coast Guard to respond to changing demands in a timely fashion. Thus the first phase of the analysis concentrated on identifying and assessing the impact of future trends and events which could affect surveillance requirements. A list of potential events relevant to Coast Guard surveillance requirements was developed. These major events were then evaluated via a Delphi, with the participation of experts in a variety of appropriate fields. The Delphi panel established estimated dates by which each event would have a high probability of occurrence. A Requirements Model was then constructed to quantitatively assess the time-phased, relative importance of each of the identified current and future Coast Guard surveillance requirements, by Program and overall. Once the relative importance of each surveillance requirement was established, a survey of current and future available technology was undertaken, to determine current development status, current level of application, pace of development, efficacy in meeting each surveillance requirement. Using cross-relevance matrices, a gap analysis was conducted to determine the efficacy of the technologies, as currently applied and potentially available, in meeting the most important surveillance requirements. The result was a determination of the relative importance of the technologies for Coast Guard research and development. A broad program was then structured utilizing the output of the gap analysis and insights gained during the evaluation of technologies.

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PREFACE

The authors wish to acknowledge the contribution of the participants in the Delphi conducted to evaluate future potential events. These individuals with diverse expertise, contributed insights into the future environment in general and the marine environment specifically. Recognition of their contribution is extended to Mr. Alvin Temin, Mr. Gerard P. Yoest, Capt. J. E. Coulter, Capt. R. T. Platt, Jr., Mr. Lawrence Nivert, Cdr. G. Barton, Cdr. L. E. Telfer, Capt. G. P. Sherburne, Cdr. R. S. Palmer, Jr., Capt. D. B. Charter, Mr. Douglas G. Conley, and Lt. Thomas S. Marhevko of the U. S. Coast Guard; Mr. Virgil W. Rinehart, Mr. James Gross of MARAD; Mr. Walter Hahn of the Library of Congress; Dr. Kenneth Simmons of Charles Williams, Inc.; Dr. Tom Cotton of the Office of Technology Assessment; Dr. Melvin Chiogioji of the Department of Energy; and Dr. Paul Lefcourt of the Environmental Protection Agency.

The second phase of this study required an analysis of currently and potentially available surveillance technologies. Valuable insights into these technologies and their stages and rates of development were provided by Mr. Harris B. Stone and Capt. Robert S. Denbigh of the R&D Plans Division, Office of the Chief of Naval Operations; Dr. S. G. Reed, Jr. and Mr. Ben Friedman of the Office of Naval Research; Mr. Carey D. Smith, Sonar Technology Division, NAVSEA Systems Command; Mr. John Giblin, Planning Appraisal and Financial Management Division, NAVSEA Systems Command; and Mr. Don Dick, Naval Surface Weapons Center, White Oak, Maryland. These individuals made an invaluable contribution in assuring an up-to-date assessment of current and future surveillance technologies.

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METRIC CONVERSION FACTORS

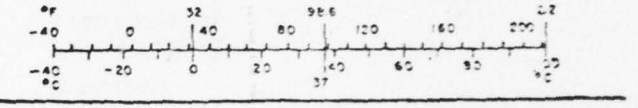
Approximate Conversions to Metric Measures

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

*1 in. = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

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



To convert from	to	Multiply by
angstrom	meter (m)	1.000 000*E-10
micron	meter (m)	1.000 000*E-06

Multiplication Factor	Prefix	Symbol
1 000 000 000 000 000 000 = 10^{18}	exa[a]	E
1 000 000 000 000 000 = 10^{15}	peta[a]	P
1 000 000 000 000 = 10^{12}	tera	T
1 000 000 000 = 10^{9}	giga	G
1 000 000 = 10^{6}	mega	M
1 000 = 10^{3}	kilo	k
100 = 10^{2}	hecto[b]	h
10 = 10^{1}	deka[b]	da
0.1 = 10^{-1}	deci[b]	d
0.01 = 10^{-2}	centi[b]	c
0.001 = 10^{-3}	milli	m
0.000 001 = 10^{-6}	micro	μ
0.000 000 001 = 10^{-9}	nano	n
0.000 000 000 001 = 10^{-12}	pico	p
0.000 000 000 000 001 = 10^{-15}	femto	f
0.000 000 000 000 000 001 = 10^{-18}	atto	a

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GLOSSARY

Coast Guard Objectives: Broad statements of organizational purpose as established by the Coast Guard.

Operating Program: As established by the Coast Guard in CG-411 (Planning and Programming Manual).

Program Activity (PA): A distinct surveillance-related operation related to an Operating Program.

Surveillance Function: A surveillance-related task to be performed, namely:

- **Detect** - to determine the presence or absence of the feature which is most significant or primary to the program activity.
- **Locate** - to determine the position of the thing of interest relative to the detection device in terms of range, bearing, or vertical angle.
- **Identify** - to detect features of secondary significance which describe the primary feature in terms of "who" or "what".
- **Observe** - to detect features of tertiary significance, i.e., necessary amplifying information.

Surveillance Information Element (SIE): A specific surveillance objective or object.

Surveillance Requirement: A statement of need consisting of a Surveillance Function plus a Surveillance Information Element, e.g., **Detect**: large vessel.

CHAPTER 1 - INTRODUCTION

In this era of limited resources and increasing importance of the marine environment, the U. S. Coast Guard is faced with the challenge of meeting ever-growing surveillance requirements efficiently and effectively. In the past, the Coast Guard has concentrated mainly on developing surveillance systems to meet the needs of a specific Operating Program without prior planning to capture second and third-order benefits through application of the system developed to other Programs or needs. What is needed is a method to permit the Coast Guard to identify future surveillance requirements soon enough to permit timely and appropriate action (i.e., to provide appropriate systems to the field by the time they are needed) and which allows the Coast Guard to develop multimission systems which provide efficient utilization of available resources to meet future surveillance requirements.

The objectives of this study are to provide a multimission assessment of possible Coast Guard surveillance requirements over the next 25 years in 5-year increments; to provide a forecast of possible surveillance-related Program Standards where sufficient confidence exists to predict a future value; and to develop a Coast Guard surveillance R&D program. The thrust of these objectives is twofold: first, to develop surveillance requirements and second, to develop an appropriate Coast Guard surveillance R&D program to satisfy these requirements.

Several major assumptions have been made and provide a framework for the entire study. These assumptions are:

A general war will not occur.

An economic collapse of the West will not occur.

The Coast Guard will remain a component of the armed forces of the United States.

The Coast Guard will continue as a single organizational entity.

The Coast Guard's primary functions will remain centered around civil marine and maritime matters.

The Coast Guard will retain its military functions.

Part I of the analysis focuses on the first objective: to identify surveillance requirements over the next 25 years, in 5-year increments. In the analysis, consideration has been given to anticipated future trends and events which would affect the Coast Guard's surveillance requirements, as well as Coast Guard Objectives and Operating Programs. Through the use of a mathematical model (Requirements Model), the relative importance of each of the identified future surveillance requirements has been evaluated. The net output of this evaluation is a list of time-phased, weighted and ranked surveillance requirements aggregated by Program, and overall. The entire analytical procedure and results of this part of the study are contained in Volume 1, Chapters 2-7. Substantiating data are provided in numerous appendices in Volume 2.

During this phase of the analysis, the study team also considered the second objective: to provide a forecast of possible surveillance-related Program Standards where sufficient confidence exists to predict a future value. An examination of current Program Standards reveals that there are no current standards that fall wholly into the class of "surveillance-related." That is, Program Standards are management-oriented, and surveillance is an integral part of many standards, yet the surveillance aspect is only a part, and sometimes an indistinguishable (or implicit) part of a Program Standard for an Operating Program. Because of the nature of Program Standards, the study team felt that any attempt to define new Program Standards would be counterproductive, and that the results of such an effort would not be useful to the Coast Guard. Chapter 3 of this report discusses the issue of Program Standards in more depth.

The third objective of the study was to develop a Coast Guard surveillance R&D Program, which would satisfy the surveillance requirements, identified in Part I, most effectively. The analysis commenced with an evaluation of technologies potentially available

during the time frame of interest. Candidate technologies were evaluated to determine their capabilities, state of development and pace of development. A comparison (gap analysis) of the efficacy of the technologies, as currently applied and potentially available, in meeting the most important surveillance requirements identified in Part I was employed to determine the relative importance of the technologies for Coast Guard research and development. The R&D program has been structured utilizing the output of the gap analysis and insights gained during the evaluation of technologies. The analysis in this phase is presented in Part II of Volume 1, Chapters 8-12. Numerous appendices in Volumes 2 and 3 provide more detailed information on specific technologies, etc. Every effort has been made to present the report in unclassified form. All classified material is separately bound in Volume 3.

PART 1 - SURVEILLANCE REQUIREMENTS

CHAPTER 2 - OVERVIEW OF REQUIREMENTS DEVELOPMENT

This chapter presents a broad overview of the approach taken in developing a list of future Coast Guard surveillance requirements. Detailed discussions of the analysis and results are contained in Chapters 3 through 7.

The purpose of this analysis was to develop a list of major Coast Guard surveillance requirements in the context of the future environment. The goal was to obtain a list of surveillance requirements with each entry weighted according to its importance to U.S. Coast Guard goals and programs, and the future demands which might be placed upon the Service in this area. To this end, a systems approach (Figure 2-1) to requirements development has been taken, with a mathematical model at the core, to allow for incorporation of all these significant internal and external factors. Current surveillance requirements and operations, and future developments (trends and events), provide inputs to the model; outputs are weighted, ranked, and time-phased future surveillance requirements.

Three major tasks were involved in this phase of the analysis.

1. Review of Current Surveillance Requirements
2. Evaluation of Future Developments
3. Quantitative Evaluation of Future Surveillance Requirements

Each of these tasks is discussed below briefly.

Review of Current Surveillance Requirements. Current Coast Guard operations, described by surveillance-related Program Standards for Operating Programs, provide the basis for the Requirements Model. Beginning with definitions of necessary terms, Chapter 3 develops a taxonomy of current surveillance requirements. The resulting baseline list of current surveillance requirements by Program, and across Programs, provides a structure for developing future surveillance requirements, and a basis for the gap analysis in Part II of the study.

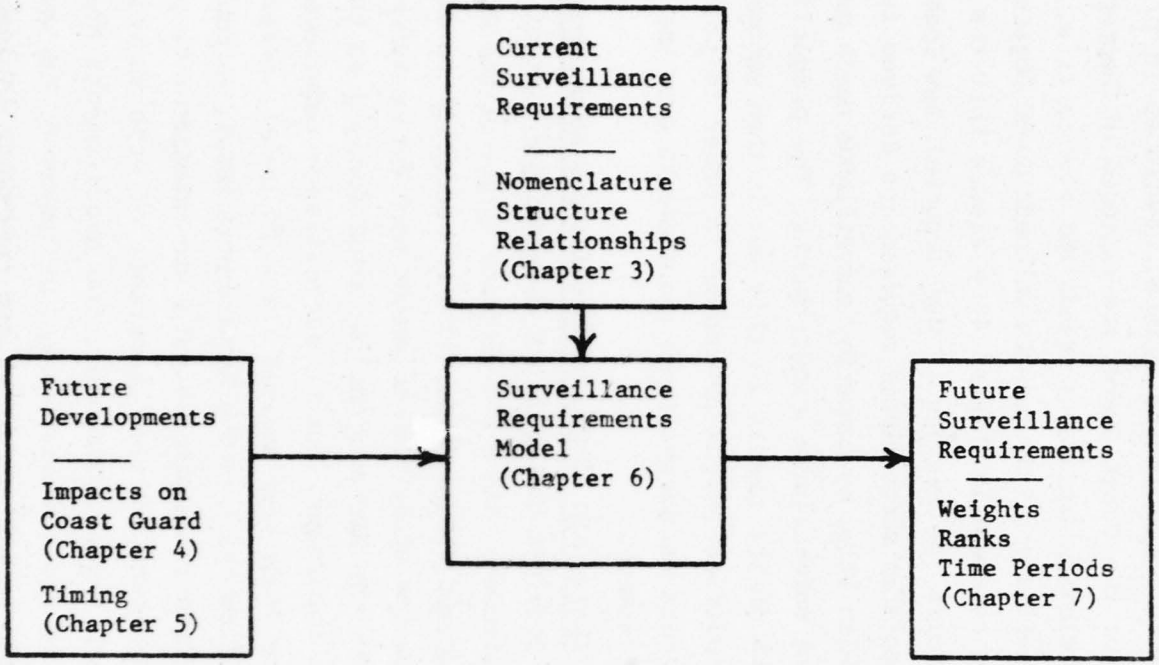


FIGURE 2-1. SURVEILLANCE REQUIREMENTS DEVELOPMENT

Evaluation of Future Developments. The nature of future trends and events may strongly affect (or change) U.S. Coast Guard surveillance requirements over the next 25 years. Consideration of these external forces is essential to assure that the proposed R&D program is responsive to changing demands. The surveillance implications of future trends and events, developed in previous futures studies for the Coast Guard, are explored in Chapters 4 and 5. After filtering clearly extraneous trends and events (i.e., those irrelevant to surveillance), the impacts on Coast Guard Objectives of a set of events are assessed in Chapter 4 to assure that the events selected would affect the Service if they occurred. New Coast Guard activities and associated surveillance requirements derived from the events are also identified by comparing surveillance needs generated by events to current surveillance requirements. The probability of occurrence of each of the events in this set is then estimated, in Chapter 5, by a modified Delphi procedure in order to phase the impacts of the events on surveillance requirements over the next 25 years in 5-year increments.

Quantitative Evaluation of Future Surveillance Requirements. The foregoing analysis provides the basis for developing a list of future surveillance requirements. Since the ultimate target of the study was to develop a time-phased R&D program, it was essential to devise a technique to allow the study team to weight each future surveillance requirement so that the R&D program proposed focused on the most critical (or most important) future surveillance requirements. To accomplish this, the study team devised a scoring model, referred to in the study and flow chart as The Requirements Model. Variables and relationships developed in Chapters 3 and 4 are integrated to produce a quantitative measure of the importance of each surveillance requirement in each 5-year increment. The Requirements Model is described, verbally and mathematically, in Chapter 6. The weighting or scoring of certain variables, which are necessary in describing the mathematical chain of effects from event occurrence to surveillance requirement, is also fully explained.

Requirements Model outputs are presented and analyzed in Chapter 7. By exercising the model for each of the 5-year increments,

a picture of changes in future surveillance requirements is obtained for each Operating Program and across all Programs. The output of the Requirements Model (time-phased, weighted, and ranked surveillance requirements) provides a basis for assessing, in Part II, the relative merits of technologies in satisfying future surveillance requirements.

CHAPTER 3 - CURRENT SURVEILLANCE REQUIREMENTS

A study to identify surveillance technologies warranting research and development effort properly starts with consideration of operational surveillance requirements. Establishment of current Coast Guard surveillance requirements has been initiated by the MAR study[1] based on a review of published Operating Program Standards.

The MAR study searched Coast Guard documents and extracted all available information pertinent to surveillance-related Operating Program Standards and performance levels. While the information obtained provides a sound foundation for initially planning a multimission surveillance R&D program, surveillance needs are interwoven with other needs (such as deterrence) in the language and concepts of Operating Program Standards. This is to be expected since Program Standards and performance levels are management-oriented expressions for the efficient allocation and use of existing resources to satisfy the total objectives of Operating Programs. As a result, needs which are purely surveillance can become indistinguishable from other needs. An ELT Program Standard provides a typical example:[2]

Description	Vessel Days	WPB Days	A/C Hours
Detect/Deter 95% of Foreign Violations of Laws and Treaties Involving Fisheries	2719	210	9032 10 SRR

"Detect" implies surveillance (but only partially; inspection of logs and records and instruction for their proper maintenance are not surveillance functions although they are part of the "detect" process). "Deter" does not imply surveillance, although the presence of a surveillance platform (cutter or aircraft) may act as a deterrent to illegal activity.

The MAR study applied a liberal interpretation of surveillance implications of Program Standards and identified 11 Operating Programs having surveillance requirements (Table 3-1). Because of the

TABLE 3-1. COAST GUARD OPERATING PROGRAMS WITH SURVEILLANCE REQUIREMENTS

AN	-	Short Range Aids to Navigation
BA	-	Bridge Administration
CVS	-	Commercial Vessel Safety
ELT	-	Enforcement of Laws and Treaties
IO	-	Ice Operations
MEP	-	Marine Environmental Protection
MO/MP	-	Military Operations/Preparedness
MSA	-	Marine Science Activities
PSS	-	Port Safety and Security
RBS	-	Recreational Boating Safety
SAR	-	Search and Rescue

ambiguities mentioned above, 6 pages of questions seeking necessary clarification by program managers were also framed. The present study has proceeded with responses to these questions still outstanding.

Selection of programs with surveillance requirements is further complicated where the sensing necessary to meet particular Program Standards may or may not be performed remotely. Tests or inspections which cannot be performed remotely are generally excluded as surveillance requirements but, since future technology may permit remote performance of some of these tests or inspections, the list of Operating Programs with surveillance requirements developed in the MAR study has been retained for the present study.

Accepting these 11 Operating Programs, it is necessary to better define "surveillance." This is not a straightforward task, however, since the term is employed in various ways to suit the needs of particular users. A dictionary definition "the act of watching or the state of being watched; a very close watch; a spying supervision"[3] is not very useful. Since the term is frequently used in a military context, the DOD Dictionary of Military and Associated Terms (JCS Pub. No. 1) has been consulted, but here again the definition is imprecise. The expression "systematic observation," however, does appear more than once among the surveillance entries.

A number of terms with surveillance implications has been used by Coast Guard program managers in describing Operating Program Standards[4]. In searching Program Standards for those which are related to surveillance, a list of terms has been developed, namely: detect, locate, identify, observe, patrol, and monitor. Nowhere, however, have these terms been defined.

Lacking generally accepted definitions, a concept of surveillance which is useful to the study has had to be developed. It appears that "surveillance" essentially means "detection," i.e., the act of determining the presence or absence of something of interest to the observer. A level of importance or significance also attaches to surveillance depending upon the perspective of the observer. For instance, if a vessel is the object of interest, determination of the presence or absence of a vessel is of first importance; given that a vessel is present, the observer next considers a second level of

importance, such as detection of some feature or characteristic which will establish the nationality of the vessel; given the presence of a vessel flying the certain flag, observer interest turns to other matters, a third level of importance, such as detecting something else which will identify the vessel by type. However, the surveillance act performed, at whatever level of importance, may be thought of as detection.

The concept that surveillance means detection has greatest usefulness when surveillance technologies are considered. When considering surveillance requirements expressed by program managers, however, the concept may not be so useful because it conflicts with the broader terminology in general use. For purposes of the present study, surveillance requirements are categorized according to the following Surveillance Functions:

- Detect - to determine the presence or absence of the feature which is most significant or primary to the program activity.

- Locate - to determine the position of the thing of interest relative to the detection device in terms of range, bearing, or vertical angle; determination of geographical position is also included although this is strictly the function of a non-surveillance system or equipment.

- Identify - to detect features of secondary significance which describe the primary feature in terms of "who" or "what".

- Observe - to detect features of tertiary significance, i.e., necessary amplifying information.

These four functions appear in the list of terms describing Program Standards mentioned above. The two remaining terms, "monitor" and "patrol", are not used in this study. It seems quite clear that "monitor" implies detection integrated with time, i.e., detect again, or detect periodically, or detect continuously. The function to be performed, whether once or frequently, is to detect; "monitor" is therefore redundant. The final term "patrol" is ambiguous; it implies the action of a vehicle carrying detection devices rather than any specific surveillance function.

A Surveillance Function alone does not adequately describe a surveillance requirement. To complete a statement of requirement, the Function (a verb) needs an object, defined in the present study as a Surveillance Information Element (SIE). A Surveillance Function and an SIE, taken together, comprise a surveillance requirement. SIEs have been developed for each Function. The resulting taxonomy of surveillance requirements (Table 3-2) incorporates both current SIEs and future SIEs identified in later chapters.

With surveillance requirements in clearer focus, attention can now be turned to their application to current Coast Guard operations, i.e., to the 11 Operating Programs previously identified. Each Operating Program consists of a number of related but distinct operations or activities; some of these operations are surveillance-related, some are not. Search activities of the SAR Program, for instance, are manifestly surveillance-related, although rescue activities are not. Distinct surveillance-related operations are designated Program Activities in this study. Current Program Activities have been derived from various sources, principally references 43 and 45. Current Program Activities are listed and briefly described in Table 3-3.

A structure and summary of current surveillance requirements is given in Table 3-4. The table describes each current surveillance requirement in terms of Operating Program, Program Activity, Surveillance Function and SIE. By looking at all entries for each Program Activity, a complete qualitative picture of current surveillance requirements may be obtained.

To summarize, current Operating Program Standards and other documents have been reviewed in order to establish a baseline structure for use in investigating future surveillance requirements. Operating Programs with surveillance requirements have been identified. Within these Programs, surveillance-related operations have been isolated and termed Program Activities. Surveillance Functions (detect, locate, identify, observe) have been defined, and a list of Surveillance Information Elements (SIEs) has been developed. A surveillance requirement has been defined as a Surveillance Function plus an SIE. Finally, a current surveillance

baseline relating Operating Programs, Program Activities and surveillance requirements has been constructed.

TABLE 3-2

SURVEILLANCE FUNCTIONS, SURVEILLANCE INFORMATION ELEMENTS (SIEs), AND SIE CODES

SIE CODE	SIE DESCRIPTION
	SURVEILLANCE FUNCTION: DETECT
001	Airborne Aircraft, Missile, Airship
002	Large Vessel (150' +)
003	Medium Sized Vessel (40' - 150')
004	Small Vessel (16' - 40'), Metal Buoy, Visible Object (Beacon), Large Iceberg, Afloat Seaplane
005	Man in Water, Non-Metallic Buoy, Fish Trap Marker, Growler, Ditched Aircraft
006	Ice Field, Ice Jam
007	Solid Pollutant, Tarball
008	Diver (Underwater Swimmer)
009	Small Submerged Submersible, Mine, Sunken Vessel
010	Large Submerged Submarine
011	Sea Bottom
012	Sea Surface
013	Liquid Pollutant
014	Gaseous Pollutant
015	Electromagnetic Emission: Radio (10 kHz - 30 GHz)
016	Electromagnetic Emission: Radar (200-30,000 MHz)
017	Electromagnetic Emission: Infrared (1-400 THz) (300 - 0.75 micron)
018	Electromagnetic Emission: Light (400-750 THz) (0.75 - 0.4 micron)
019	Sound Emission in Air
020	Sound Emission in Water
021	Nuclear Radiation: Alpha and Beta Particles, Gamma Rays
	SURVEILLANCE FUNCTION: LOCATE
022	Range or bearing
023	Range and bearing
024	Altitude or depth
025	Geographical position

TABLE 3-2. (Continued).

SIE CODE	SIE DESCRIPTION
	SURVEILLANCE FUNCTION: IDENTIFY
026	Name or identifying number
027	Flag (US or foreign)
028	Friend or foe
029	Type
030	Color
031	Shape
032	Frequency
033	Characteristic Code
	SURVEILLANCE FUNCTION: OBSERVE
034	Structural integrity
035	Audible/visible/radar range
036	Visibility arcs
037	Movement of object of interest
038	Transmission time schedule
039	Number of objects per time interval
040	Fishing activity
041	Fishery support operations
042	Suspicious activity: Hovering
043	Suspicious activity: Transferring cargo
044	Suspicious activity: Fleeing
045	Suspicious activity: Discharging pollutant
046	Hostile Activity
047	Hazardous activity
048	Fish Catch: Species
049	Fish Catch: Fish Size
050	Fish Catch: Quantity
051	Contraband: Chemical, Biological, Radiological Devices
052	Contraband: Drugs
053	Contraband: Weapons and Munitions
054	Illegal Aliens
055	Ice Thickness
056	Size of object
057	Area covered by object(s) of interest
058	Seas and Swells: Height

TABLE 3-2. (Continued).

SURVEILLANCE FUNCTION: OBSERVE

SIE CODE	SIE DESCRIPTION
059	Seas and Swells: Period
060	Profiles: Depth vs Temperature
061	Profiles: Depth vs Salinity
062	Surface Weather: Temperature
063	Surface Weather: Pressure
064	Surface Weather: Humidity
065	Cloud Type
066	Wind Velocity
067	Nature of Distress: Disabled or Injured
068	Nature of Distress: Afire
069	Nature of Distress: Sinking
070	Nature of Distress: Aground
071	Nature of Distress: Sunk

TABLE 3-3. CURRENT SURVEILLANCE-RELATED PROGRAM ACTIVITIES

PROGRAM	PROGRAM ACTIVITY	PA CODE	REMARKS
AN	Buoy Surveillance	1	The purpose of AN surveillance is to determine whether established aids are functioning properly.
	Beacon Surveillance	2	
	Surveillance of Lights	3	
	Radio Beacon Surveillance	4	
	Fog Signal Surveillance	5	
BA	Bridge Traffic Surveillance	10	
CVS	Offshore Platform Inspection	13	
ELT	Fishing Vessel Surveillance	20	Gear conflict is mutual interference resulting from concurrent use of different fishing techniques in the same area.
	Gear Conflict Surveillance	21	
	Anti-Smuggling Surveillance	22	
IO	Ice Surveillance	30	
	Flood (Ice Jam) Surveillance	31	
MEP	Coastal Pollution Surveillance	40	
	Harbor Pollution Surveillance	41	
MOMP	AAW Surveillance	50	AAW: Antiair Warfare
	ASUW Surveillance	51	ASUW: Antisurface Warfare
	ASW Surveillance	52	ASW: Antisubmarine Warfare
	NGFS Surveillance	53	NGFS: Naval Gunfire Support
	Disaster Control Surveillance	54	
MSA	Iceberg Surveillance	60	
	Sea Temperature Surveys	61	
	Ocean Soundings Program	62	
	Standard Oceanographic Sections	63	
	Bathythermograph Observations	64	
	Tarball Observations	65	
	Surface Current Observations	66	
	Nat'l Data Bucy Surveillance	67	
	Surface Weather Observations	68	

TABLE 3-3 (Continued)

PROGRAM	PROGRAM ACTIVITY	PA CODE	REMARKS
PSS	Facility Inspection	75	Special interest vessel surveillance.
	Special Vessel Surveillance	76	
	Port and Waterway Surveillance	77	
	Control Selected Vessel Movements	78	
	Vessel Traffic Services	79	
RBS	Regatta Surveillance	87	
SAR	Alerting and Locating Systems	90	
	Surface Search	91	

TABLE 3-4. CURRENT PROGRAM ACTIVITIES AND SURVEILLANCE REQUIREMENTS

PROG	PA	PROGRAM ACTIVITY	FUNCTION	SIE	SURVEILLANCE INFORMATION ELEMENT
AN	1	BUOY SURVEILLANCE	DETECT	004	METAL BUOY
AN	1	BUOY SURVEILLANCE	DETECT	005	NON-METALLIC BUOY
AN	1	BUOY SURVEILLANCE	LOCATE	025	GEOGRAPHICAL POSITION OF BUOY
AN	1	BUOY SURVEILLANCE	IDENTIFY	026	NUMBER OF BUOY
AN	1	BUOY SURVEILLANCE	IDENTIFY	030	COLOR OF BUOY
AN	1	BUOY SURVEILLANCE	IDENTIFY	031	SHAPE OF BUOY
AN	2	BEACON SURVEILLANCE	DETECT	004	BEACON, VISUAL OR RADAR
AN	2	BEACON SURVEILLANCE	IDENTIFY	026	NUMBER OF BEACON
AN	2	BEACON SURVEILLANCE	IDENTIFY	030	COLOR OF BEACON
AN	2	BEACON SURVEILLANCE	IDENTIFY	031	SHAPE OF BEACON
AN	2	BEACON SURVEILLANCE	OBSERVE	035	VISIBLE OR RADAR DETECTION RANGE OF BEACON
AN	2	BEACON SURVEILLANCE	OBSERVE	036	VISIBILITY ARCS OF BEACON, IF APPLICABLE
AN	3	SURVEILLANCE OF LIGHTS	DETECT	018	MAJOR OR MINOR LIGHT OR LIGHTED BUOY
AN	3	SURVEILLANCE OF LIGHTS	IDENTIFY	030	COLOR OF LIGHT
AN	3	SURVEILLANCE OF LIGHTS	IDENTIFY	033	LIGHT CHARACTERISTIC
AN	3	SURVEILLANCE OF LIGHTS	OBSERVE	035	VISIBLE RANGE OF LIGHT
AN	3	SURVEILLANCE OF LIGHTS	OBSERVE	036	VISIBILITY ARCS OF LIGHT
AN	3	SURVEILLANCE OF LIGHTS	OBSERVE	038	TRANSMISSION TIME SCHEDULE OF LIGHT EMISSIONS
AN	4	RADIO BEACON SURVEILLANCE	DETECT	015	RADIO BEACON SIGNAL
AN	4	RADIO BEACON SURVEILLANCE	IDENTIFY	032	FREQUENCY OF RADIO BEACON SIGNAL
AN	4	RADIO BEACON SURVEILLANCE	IDENTIFY	033	CHARACTERISTIC CODE OF RADIO BEACON SIGNAL
AN	4	RADIO BEACON SURVEILLANCE	OBSERVE	038	TRANSMISSION TIME SCHEDULE OF RADIO BEACON SIGNAL
AN	5	FOG SIGNAL SURVEILLANCE	DETECT	019	FOG SIGNAL
AN	5	FOG SIGNAL SURVEILLANCE	IDENTIFY	033	CHARACTERISTIC CODE OF FOG SIGNAL
AN	5	FOG SIGNAL SURVEILLANCE	OBSERVE	035	AUDIBLE RANGE OF FOG SIGNAL
AN	5	FOG SIGNAL SURVEILLANCE	OBSERVE	038	TRANSMISSION TIME SCHEDULE OF FOG SIGNAL
BA	10	BRIDGE TRAFFIC SURVEILLANCE	DETECT	002	LARGE VESSELS USING WATERWAY
BA	10	BRIDGE TRAFFIC SURVEILLANCE	DETECT	003	MEDIUM-SIZED VESSELS USING WATERWAY
BA	10	BRIDGE TRAFFIC SURVEILLANCE	LOCATE	022	BRIDGE-TO-VESSEL RANGE
BA	10	BRIDGE TRAFFIC SURVEILLANCE	OBSERVE	039	NUMBER OF TRANSITING VESSELS PER UNIT TIME
ELT	20	FISHING VESSEL SURVEILLANCE	DETECT	002	LARGE VESSEL
ELT	20	FISHING VESSEL SURVEILLANCE	DETECT	003	MEDIUM-SIZED VESSEL
ELT	20	FISHING VESSEL SURVEILLANCE	LOCATE	025	GEOGRAPHICAL POSITION OF FISHING VESSEL
ELT	20	FISHING VESSEL SURVEILLANCE	IDENTIFY	026	NAME OR NUMBER OF FISHING VESSEL
ELT	20	FISHING VESSEL SURVEILLANCE	IDENTIFY	027	NATIONALITY (FLAG) OF FISHING VESSEL
ELT	20	FISHING VESSEL SURVEILLANCE	IDENTIFY	029	TYPE OF VESSEL; TYPE OF FISHING VESSEL
ELT	20	FISHING VESSEL SURVEILLANCE	OBSERVE	037	FISHING VESSEL MOVEMENT
ELT	20	FISHING VESSEL SURVEILLANCE	OBSERVE	040	FISHING ACTIVITY (GEAR AND TECHNIQUE)
ELT	20	FISHING VESSEL SURVEILLANCE	OBSERVE	041	FISHERY SUPPORT OPERATIONS
ELT	20	FISHING VESSEL SURVEILLANCE	OBSERVE	044	SUSPICIOUS ACTIVITY (FLEEING)
ELT	20	FISHING VESSEL SURVEILLANCE	OBSERVE	046	SPECIES OF FISH CAUGHT
ELT	20	FISHING VESSEL SURVEILLANCE	OBSERVE	049	SIZE OF FISH CAUGHT
ELT	20	FISHING VESSEL SURVEILLANCE	OBSERVE	050	QUANTITY OF FISH CAUGHT
ELT	21	GEAR CONFLICT SURVEILLANCE	DETECT	002	LARGE VESSEL
ELT	21	GEAR CONFLICT SURVEILLANCE	DETECT	003	MEDIUM-SIZED VESSEL
ELT	21	GEAR CONFLICT SURVEILLANCE	DETECT	004	SMALL VESSEL
ELT	21	GEAR CONFLICT SURVEILLANCE	DETECT	005	FISH TRAP MARKER
ELT	21	GEAR CONFLICT SURVEILLANCE	LOCATE	025	GEOGRAPHICAL POSITION OF VESSELS AND MARKERS
ELT	21	GEAR CONFLICT SURVEILLANCE	IDENTIFY	026	FISHING VESSEL NAME OR NUMBER; MARKER NUMBER
ELT	21	GEAR CONFLICT SURVEILLANCE	IDENTIFY	027	NATIONALITY (FLAG) OF FISHING VESSEL
ELT	21	GEAR CONFLICT SURVEILLANCE	IDENTIFY	029	TYPE OF VESSEL; TYPE OF FISHING VESSEL
ELT	21	GEAR CONFLICT SURVEILLANCE	OBSERVE	037	FISHING VESSEL MOVEMENT

TABLE 3-4. (Continued).

PROG	PA	PROGRAM ACTIVITY	FUNCTION	SIE	SURVEILLANCE INFORMATION ELEMENT
ELT	21	GEAR CONFLICT SURVEILLANCE	OBSERVE	040	FISHING ACTIVITY (GEAR AND TECHNIQUE)
ELT	21	GEAR CONFLICT SURVEILLANCE	OBSERVE	047	HAZARDOUS ACTIVITY
ELT	22	ANTI-SMUGGLING SURVEILLANCE	DETECT	002	LARGE VESSEL
ELT	22	ANTI-SMUGGLING SURVEILLANCE	DETECT	003	MEDIUM-SIZED VESSEL
ELT	22	ANTI-SMUGGLING SURVEILLANCE	DETECT	004	SMALL VESSEL
ELT	22	ANTI-SMUGGLING SURVEILLANCE	LOCATE	023	RANGE AND BEARING TO SMUGGLING VESSEL
ELT	22	ANTI-SMUGGLING SURVEILLANCE	LOCATE	025	GEOGRAPHICAL POSITION OF SMUGGLING VESSEL
ELT	22	ANTI-SMUGGLING SURVEILLANCE	IDENTIFY	026	NAME OR NUMBER OF SMUGGLING VESSEL
ELT	22	ANTI-SMUGGLING SURVEILLANCE	IDENTIFY	027	NATIONALITY (FLAG) OF SMUGGLING VESSEL
ELT	22	ANTI-SMUGGLING SURVEILLANCE	IDENTIFY	029	VESSEL TYPE
ELT	22	ANTI-SMUGGLING SURVEILLANCE	OBSERVE	037	SMUGGLING VESSEL MOVEMENT
ELT	22	ANTI-SMUGGLING SURVEILLANCE	OBSERVE	042	SUSPICIOUS ACTIVITY (HOVERING)
ELT	22	ANTI-SMUGGLING SURVEILLANCE	OBSERVE	043	SUSPICIOUS ACTIVITY (TRANSFERRING CARGO)
ELT	22	ANTI-SMUGGLING SURVEILLANCE	OBSERVE	044	SUSPICIOUS ACTIVITY (FLEEING)
ELT	22	ANTI-SMUGGLING SURVEILLANCE	OBSERVE	052	CONTRABAND (DRUGS)
ELT	22	ANTI-SMUGGLING SURVEILLANCE	OBSERVE	053	CONTRABAND (WEAPONS AND MUNITIONS)
ELT	22	ANTI-SMUGGLING SURVEILLANCE	OBSERVE	054	ILLEGAL ALIENS
IO	30	ICE SURVEILLANCE	DETECT	006	ICE FIELDS
IO	30	ICE SURVEILLANCE	LOCATE	025	GEOGRAPHICAL POSITION OF ICE FIELDS
IO	30	ICE SURVEILLANCE	IDENTIFY	029	TYPE OF ICE
IO	30	ICE SURVEILLANCE	OBSERVE	037	ICE MOVEMENT
IO	30	ICE SURVEILLANCE	OBSERVE	055	ICE THICKNESS
IO	30	ICE SURVEILLANCE	OBSERVE	057	AREA COVERED BY ICE
IO	31	FLOOD (ICE JAM) SURVEILLANCE	DETECT	006	ICE JAMS
IO	31	FLOOD (ICE JAM) SURVEILLANCE	LOCATE	025	GEOGRAPHICAL POSITION OF ICE JAMS
IO	31	FLOOD (ICE JAM) SURVEILLANCE	OBSERVE	037	ICE MOVEMENT
IO	31	FLOOD (ICE JAM) SURVEILLANCE	OBSERVE	055	ICE THICKNESS
IO	31	FLOOD (ICE JAM) SURVEILLANCE	OBSERVE	057	AREA COVERED BY ICE
MEP	40	COASTAL POLLUTION SURVEILLANCE	DETECT	013	LIQUID POLLUTANT
MEP	40	COASTAL POLLUTION SURVEILLANCE	LOCATE	025	GEOGRAPHICAL POSITION OF POLLUTANT
MEP	40	COASTAL POLLUTION SURVEILLANCE	IDENTIFY	029	TYPE OF POLLUTANT
MEP	40	COASTAL POLLUTION SURVEILLANCE	OBSERVE	037	MOVEMENT OF POLLUTANT
MEP	40	COASTAL POLLUTION SURVEILLANCE	OBSERVE	045	APPARENT SOURCE OF POLLUTANT
MEP	40	COASTAL POLLUTION SURVEILLANCE	OBSERVE	057	AREA COVERED BY POLLUTANT
MEP	41	HARBOR POLLUTION SURVEILLANCE	DETECT	013	LIQUID POLLUTANT
MEP	41	HARBOR POLLUTION SURVEILLANCE	LOCATE	025	GEOGRAPHICAL POSITION OF POLLUTANT
MEP	41	HARBOR POLLUTION SURVEILLANCE	IDENTIFY	029	TYPE OF POLLUTANT
MEP	41	HARBOR POLLUTION SURVEILLANCE	OBSERVE	037	MOVEMENT OF POLLUTANT
MEP	41	HARBOR POLLUTION SURVEILLANCE	OBSERVE	045	APPARENT SOURCE OF POLLUTANT
MEP	41	HARBOR POLLUTION SURVEILLANCE	OBSERVE	057	AREA COVERED BY POLLUTANT
MEP	42	INT'L POLLUTION SURVEILLANCE	DETECT	013	LIQUID POLLUTANTS
MEP	42	INT'L POLLUTION SURVEILLANCE	LOCATE	025	GEOGRAPHICAL POSITION OF POLLUTANT
MEP	42	INT'L POLLUTION SURVEILLANCE	IDENTIFY	029	TYPE OF POLLUTANT
MEP	42	INT'L POLLUTION SURVEILLANCE	OBSERVE	037	MOVEMENT OF POLLUTANT
MEP	42	INT'L POLLUTION SURVEILLANCE	OBSERVE	045	APPARENT SOURCE OF POLLUTANT
MEP	42	INT'L POLLUTION SURVEILLANCE	OBSERVE	057	AREA COVERED BY POLLUTANT
MOMP	50	AAW SURVEILLANCE	DETECT	001	AIRCRAFT, MISSILE
MOMP	50	AAW SURVEILLANCE	LOCATE	023	RANGE AND BEARING OF AIRCRAFT/MISSILE
MOMP	50	AAW SURVEILLANCE	LOCATE	024	ALTITUDE OF AIRCRAFT/MISSILE
MOMP	50	AAW SURVEILLANCE	IDENTIFY	028	CHARACTER OF AIRCRAFT (FRIEND OR FOE)
MOMP	50	AAW SURVEILLANCE	IDENTIFY	029	TYPE OF AIRCRAFT OR MISSILE
MOMP	50	AAW SURVEILLANCE	OBSERVE	037	MOVEMENT OF AIRCRAFT OR MISSILE

TABLE 3-4. (Continued).

PROG	PA	PROGRAM ACTIVITY	FUNCTION	SIE	SURVEILLANCE INFORMATION ELEMENT
MOMP	50	AAW SURVEILLANCE	OBSERVE	046	HOSTILE AIRCRAFT ACTIVITY
MOMP	51	ASUW SURVEILLANCE	DETECT	002	LARGE VESSEL
MOMP	51	ASUW SURVEILLANCE	DETECT	003	MEDIUM-SIZED VESSEL
MOMP	51	ASUW SURVEILLANCE	DETECT	004	SMALL VESSEL
MOMP	51	ASUW SURVEILLANCE	LOCATE	023	RANGE AND BEARING OF VESSEL
MOMP	51	ASUW SURVEILLANCE	IDENTIFY	026	VESSEL CHARACTER (FRIEND OR FOE)
MOMP	51	ASUW SURVEILLANCE	IDENTIFY	029	VESSEL TYPE OR CLASS
MOMP	51	ASUW SURVEILLANCE	OBSERVE	037	VESSEL MOVEMENT
MOMP	51	ASUW SURVEILLANCE	OBSERVE	046	HOSTILE VESSEL ACTIVITY
MOMP	52	ASW SURVEILLANCE	DETECT	010	LARGE SUBMERGED SUBMARINE
MOMP	52	ASW SURVEILLANCE	LOCATE	023	RANGE AND BEARING OF SUBMARINE
MOMP	52	ASW SURVEILLANCE	LOCATE	024	DEPTH OF SUBMARINE
MOMP	52	ASW SURVEILLANCE	IDENTIFY	026	SUBMARINE CHARACTER (FRIEND OR FOE)
MOMP	52	ASW SURVEILLANCE	IDENTIFY	029	SUBMARINE TYPE OR CLASS
MOMP	52	ASW SURVEILLANCE	OBSERVE	037	SUBMARINE MOVEMENT
MOMP	52	ASW SURVEILLANCE	OBSERVE	046	HOSTILE SUBMARINE ACTIVITY
MOMP	53	NGFS SURVEILLANCE	DETECT	004	LAND TARGET OR AIMING POINT
MOMP	53	NGFS SURVEILLANCE	LOCATE	023	RANGE AND BEARING OF TARGET/AIMING POINT
MOMP	53	NGFS SURVEILLANCE	LOCATE	024	ALTITUDE OF TARGET/AIMING POINT
MOMP	53	NGFS SURVEILLANCE	LOCATE	025	GEOGRAPHICAL POSITION OF TARGET/AIMING POINT
MOMP	53	NGFS SURVEILLANCE	IDENTIFY	029	TARGET TYPE
MOMP	53	NGFS SURVEILLANCE	OBSERVE	035	FALL OF SHOT
MOMP	53	NGFS SURVEILLANCE	OBSERVE	037	TARGET MOVEMENT
MOMP	53	NGFS SURVEILLANCE	OBSERVE	046	HOSTILE ACTIVITY OF TARGET
MOMP	54	DISASTER CONTROL SURVEILLANCE	DETECT	012	FLOODED TERRAIN
MOMP	54	DISASTER CONTROL SURVEILLANCE	DETECT	014	GASEOUS CHEMICAL AGENT
MOMP	54	DISASTER CONTROL SURVEILLANCE	DETECT	017	HEAT FROM FIRES AND EXPLOSIONS
MOMP	54	DISASTER CONTROL SURVEILLANCE	DETECT	021	NUCLEAR RADIATION
MOMP	54	DISASTER CONTROL SURVEILLANCE	LOCATE	025	GEOGRAPHICAL POSITION
MOMP	54	DISASTER CONTROL SURVEILLANCE	IDENTIFY	029	TYPE OF EXPLOSIVE OR CHEMICAL AGENT
MOMP	54	DISASTER CONTROL SURVEILLANCE	OBSERVE	037	FLOOD, FIRE, FALLOUT, GAS CLOUD MOVEMENT
MOMP	54	DISASTER CONTROL SURVEILLANCE	OBSERVE	047	HAZARDOUS ACTIVITIES OF VICTIMS OR MOBS
MOMP	54	DISASTER CONTROL SURVEILLANCE	OBSERVE	056	SIZE OF NUCLEAR BURST, EXPLOSION, ETC.
MOMP	54	DISASTER CONTROL SURVEILLANCE	OBSERVE	057	AREA AFFECTED BY DISASTER
MOMP	54	DISASTER CONTROL SURVEILLANCE	OBSERVE	066	WIND VELOCITY
MOMP	54	DISASTER CONTROL SURVEILLANCE	OBSERVE	067	NATURE OF DISTRESS: DAMAGE AND INJURIES
MOMP	54	DISASTER CONTROL SURVEILLANCE	OBSERVE	068	NATURE OF DISTRESS: FIRE OR EXPLOSION
MOMP	54	DISASTER CONTROL SURVEILLANCE	OBSERVE	069	NATURE OF DISTRESS: FLOODING
MSA	60	ICEBERG SURVEILLANCE	DETECT	004	LARGE ICEBERG
MSA	60	ICEBERG SURVEILLANCE	DETECT	005	GROWLER
MSA	60	ICEBERG SURVEILLANCE	LOCATE	025	GEOGRAPHIC POSITION
MSA	60	ICEBERG SURVEILLANCE	OBSERVE	037	ICEBERG MOVEMENT
MSA	60	ICEBERG SURVEILLANCE	OBSERVE	056	SIZE OF ICEBERG
MSA	60	ICEBERG SURVEILLANCE	OBSERVE	057	ICEBERG HAZARD AREA
MSA	61	SEA TEMPERATURE SURVEYS	DETECT	017	SURFACE SEA TEMPERATURE
MSA	61	SEA TEMPERATURE SURVEYS	LOCATE	025	GEOGRAPHICAL POSITION OF OBSERVATION
MSA	62	OCEAN SOUNDINGS PROGRAM	DETECT	011	SEA BOTTOM
MSA	62	OCEAN SOUNDINGS PROGRAM	LOCATE	024	OBSERVED DEPTH
MSA	62	OCEAN SOUNDINGS PROGRAM	LOCATE	025	GEOGRAPHICAL POSITION OF OBSERVATION
MSA	63	STANDARD OCEANO. SECTIONS	DETECT	012	SEA SURFACE
MSA	63	STANDARD OCEANO. SECTIONS	LOCATE	025	GEOGRAPHICAL POSITION OF SECTION
MSA	63	STANDARD OCEANO. SECTIONS	OBSERVE	037	SURFACE CURRENT VELOCITY

TABLE 3-4. (Continued).

PROG	PA	PROGRAM ACTIVITY	FUNCTION	SIE	SURVEILLANCE INFORMATION ELEMENT
MSA	64	BATHYTHERMOGRAPH OBSERVATIONS	LOCATE	025	GEOGRAPHICAL POSITION OF OBSERVATION
MSA	64	BATHYTHERMOGRAPH OBSERVATIONS	OBSERVE	060	PRESSURE (DEPTH) VERSUS TEMPERATURE PROFILE
MSA	65	TARBALL OBSERVATIONS	DETECT	007	TARBALLS
MSA	65	TARBALL OBSERVATIONS	LOCATE	025	GEOGRAPHIC POSITION OF OBSERVATION
MSA	65	TARBALL OBSERVATIONS	OBSERVE	039	NUMBER OF TARBALLS
MSA	65	TARBALL OBSERVATIONS	OBSERVE	056	SIZE OF TARBALLS
MSA	65	TARBALL OBSERVATIONS	OBSERVE	057	SIZE OF AREA IN WHICH TARBALLS FOUND
MSA	66	SURFACE CURRENT OBSERVATIONS	DETECT	012	SEA SURFACE
MSA	66	SURFACE CURRENT OBSERVATIONS	LOCATE	025	GEOGRAPHICAL POSITION OF OBSERVATION
MSA	66	SURFACE CURRENT OBSERVATIONS	OBSERVE	037	SURFACE CURRENT VELOCITY
MSA	67	NATIONAL DATA BUOY PROGRAM	DETECT	004	DATA BUOY
MSA	67	NATIONAL DATA BUOY PROGRAM	DETECT	015	BUOY TELEMETRY TRANSMISSION
MSA	67	NATIONAL DATA BUOY PROGRAM	LOCATE	025	GEOGRAPHICAL POSITION OF BUOY
MSA	67	NATIONAL DATA BUOY PROGRAM	IDENTIFY	026	BUOY NUMBER
MSA	67	NATIONAL DATA BUOY PROGRAM	IDENTIFY	032	DATA BUOY RADIO TRANSMISSION FREQUENCY
MSA	67	NATIONAL DATA BUOY PROGRAM	IDENTIFY	033	CHARACTERISTIC OF DATA BUOY TELEMETRY SIGNAL
MSA	67	NATIONAL DATA BUOY PROGRAM	OBSERVE	038	DATA BUOY TRANSMISSION TIME SCHEDULE
MSA	68	SURFACE WEATHER OBSERVATIONS	LOCATE	025	GEOGRAPHICAL POSITION OF OBSERVATION
MSA	68	SURFACE WEATHER OBSERVATIONS	OBSERVE	037	MOVEMENT OF CLOUDS, SURFACE SWELLS
MSA	68	SURFACE WEATHER OBSERVATIONS	OBSERVE	057	CLOUD COVERAGE (PERCENT)
MSA	68	SURFACE WEATHER OBSERVATIONS	OBSERVE	058	HEIGHT OF SEAS AND SWELLS
MSA	68	SURFACE WEATHER OBSERVATIONS	OBSERVE	059	PERIOD OF SEAS AND SWELLS
MSA	68	SURFACE WEATHER OBSERVATIONS	OBSERVE	062	SURFACE WEATHER: TEMPERATURE
MSA	68	SURFACE WEATHER OBSERVATIONS	OBSERVE	063	ATMOSPHERIC PRESSURE
MSA	68	SURFACE WEATHER OBSERVATIONS	OBSERVE	064	SURFACE WEATHER: HUMIDITY
MSA	68	SURFACE WEATHER OBSERVATIONS	OBSERVE	065	CLOUD TYPES
MSA	68	SURFACE WEATHER OBSERVATIONS	OBSERVE	066	SURFACE WIND VELOCITY
PSS	75	FACILITY INSPECTION	OBSERVE	034	STRUCTURAL INTEGRITY OF FACILITY
PSS	75	FACILITY INSPECTION	OBSERVE	047	HAZARDOUS CONDITIONS OR ACTIVITIES
PSS	76	SPECIAL VESSEL SURVEILLANCE	DETECT	002	LARGE VESSEL
PSS	76	SPECIAL VESSEL SURVEILLANCE	DETECT	003	MEDIUM-SIZED VESSEL
PSS	76	SPECIAL VESSEL SURVEILLANCE	DETECT	021	NUCLEAR RADIATION
PSS	76	SPECIAL VESSEL SURVEILLANCE	LOCATE	025	GEOGRAPHICAL POSITION OF SPECIAL INTEREST VESSEL
PSS	76	SPECIAL VESSEL SURVEILLANCE	IDENTIFY	026	NAME OR NUMBER OF SPECIAL INTEREST VESSEL
PSS	76	SPECIAL VESSEL SURVEILLANCE	IDENTIFY	027	NATIONALITY (FLAG) OF SPECIAL INTEREST VESSEL
PSS	76	SPECIAL VESSEL SURVEILLANCE	IDENTIFY	029	TYPE OF VESSEL
PSS	76	SPECIAL VESSEL SURVEILLANCE	OBSERVE	037	VESSEL MOVEMENT
PSS	76	SPECIAL VESSEL SURVEILLANCE	OBSERVE	042	SUSPICIOUS ACTIVITY (HOVERING)
PSS	76	SPECIAL VESSEL SURVEILLANCE	OBSERVE	043	SUSPICIOUS ACTIVITY (TRANSFERRING CARGO)
PSS	76	SPECIAL VESSEL SURVEILLANCE	OBSERVE	046	HOSTILE ACTIVITY
PSS	76	SPECIAL VESSEL SURVEILLANCE	OBSERVE	051	CONTRABAND: CHEMICAL, BIOLOGICAL, RADIOLOGICAL DEVICES
PSS	76	SPECIAL VESSEL SURVEILLANCE	OBSERVE	053	CONTRABAND: WEAPONS AND MUNITIONS
PSS	76	SPECIAL VESSEL SURVEILLANCE	OBSERVE	054	ILLEGAL ALIENS
PSS	77	PORT AND WATERWAY SURVEILLANCE	DETECT	002	LARGE THREATENING VESSELS
PSS	77	PORT AND WATERWAY SURVEILLANCE	DETECT	003	MEDIUM-SIZED THREATENING VESSELS
PSS	77	PORT AND WATERWAY SURVEILLANCE	DETECT	004	SMALL THREATENING VESSELS
PSS	77	PORT AND WATERWAY SURVEILLANCE	DETECT	005	PERSONNEL THREATS: SURFACE
PSS	77	PORT AND WATERWAY SURVEILLANCE	DETECT	006	PERSONNEL THREATS: SUBSURFACE
PSS	77	PORT AND WATERWAY SURVEILLANCE	LOCATE	023	RANGE AND BEARING OF THREATENING VESSELS
PSS	77	PORT AND WATERWAY SURVEILLANCE	LOCATE	024	DEPTH OF SWIMMERS
PSS	77	PORT AND WATERWAY SURVEILLANCE	IDENTIFY	026	VESSEL NAME OR NUMBER

TABLE 3-4. (Continued).

PROG	PA	PROGRAM ACTIVITY	FUNCTION	SIE	SURVEILLANCE INFORMATION ELEMENT
PSS	77	PORT AND WATERWAY SURVEILLANCE	IDENTIFY	027	NATIONALITY (FLAG) OF VESSEL
PSS	77	PORT AND WATERWAY SURVEILLANCE	IDENTIFY	029	TYPE OF THREAT
PSS	77	PORT AND WATERWAY SURVEILLANCE	OBSERVE	037	MOVEMENT OF THREAT
PSS	77	PORT AND WATERWAY SURVEILLANCE	OBSERVE	042	SUSPICIOUS ACTIVITY
PSS	77	PORT AND WATERWAY SURVEILLANCE	OBSERVE	046	HOSTILE ACTIVITY
PSS	77	PORT AND WATERWAY SURVEILLANCE	OBSERVE	047	HAZARDOUS ACTIVITY
PSS	78	CONTROL SELECTED VESSEL MVMTS	DETECT	002	LARGE THREATENING/THREATENED VESSELS
PSS	78	CONTROL SELECTED VESSEL MVMTS	DETECT	003	MEDIUM-SIZED THREATENING/THREATENED VESSELS
PSS	78	CONTROL SELECTED VESSEL MVMTS	DETECT	004	SMALL THREATENING/THREATENED VESSELS
PSS	78	CONTROL SELECTED VESSEL MVMTS	LOCATE	023	RANGE AND BEARING OF THREATENING/THREATENED VESSELS
PSS	78	CONTROL SELECTED VESSEL MVMTS	LOCATE	025	GEOGRAPHICAL POSITION OF SELECTED VESSEL
PSS	78	CONTROL SELECTED VESSEL MVMTS	IDENTIFY	026	NAME OR NUMBER OF VESSELS INVOLVED
PSS	78	CONTROL SELECTED VESSEL MVMTS	IDENTIFY	027	NATIONALITIES (FLAGS) OF VESSELS INVOLVED
PSS	78	CONTROL SELECTED VESSEL MVMTS	OBSERVE	037	MOVEMENTS OF VESSELS INVOLVED
PSS	78	CONTROL SELECTED VESSEL MVMTS	OBSERVE	047	HAZARDOUS ACTIVITIES
PSS	79	VESSEL TRAFFIC SERVICES	DETECT	002	LARGE VESSEL IN VTS SYSTEM
PSS	79	VESSEL TRAFFIC SERVICES	DETECT	003	MEDIUM-SIZED VESSEL IN VTS SYSTEM
PSS	79	VESSEL TRAFFIC SERVICES	LOCATE	023	RANGE AND BEARING TO VESSELS IN VTS SYSTEM
PSS	79	VESSEL TRAFFIC SERVICES	LOCATE	025	GEOGRAPHICAL POSITION OF VESSELS IN VTS SYSTEM
PSS	79	VESSEL TRAFFIC SERVICES	IDENTIFY	026	NAMES OR NUMBERS OF VESSELS IN VTS SYSTEM
PSS	79	VESSEL TRAFFIC SERVICES	IDENTIFY	029	TYPES OF VESSELS IN VTS SYSTEM
PSS	79	VESSEL TRAFFIC SERVICES	OBSERVE	037	VESSEL MOVEMENTS
PSS	79	VESSEL TRAFFIC SERVICES	OBSERVE	039	NUMBER OF VESSELS PER TIME INTERVAL
PSS	79	VESSEL TRAFFIC SERVICES	OBSERVE	047	HAZARDOUS ACTIVITIES OR MANEUVERS
PSS	79	VESSEL TRAFFIC SERVICES	OBSERVE	056	SIZES OF VESSELS IN VTS SYSTEM
RBS	87	REGATTA SURVEILLANCE	DETECT	003	MEDIUM-SIZED PARTICIPATING/INTRUDING/ENDANGERED VESSELS
RBS	87	REGATTA SURVEILLANCE	DETECT	004	SMALL PARTICIPATING/INTRUDING/ENDANGERED VESSELS
RBS	87	REGATTA SURVEILLANCE	DETECT	005	ENDANGERED SWIMMERS
RBS	87	REGATTA SURVEILLANCE	LOCATE	023	RANGE AND BEARING OF INTRUDER
RBS	87	REGATTA SURVEILLANCE	IDENTIFY	026	NAME OR NUMBER OF INTRUDING/ENDANGERED VESSEL
RBS	87	REGATTA SURVEILLANCE	OBSERVE	037	MOVEMENT OF PARTICIPATING/INTRUDING/ENDANGERED VESSELS AND SWIMMERS
RBS	87	REGATTA SURVEILLANCE	OBSERVE	047	HAZARDOUS ACTIVITY
SAR	90	ALERTING AND LOCATING SYSTEMS	DETECT	015	RADIO TRANSMISSIONS FROM ALERTING/LOCATING DEVICE
SAR	90	ALERTING AND LOCATING SYSTEMS	DETECT	018	LIGHT EMISSIONS FROM ALERTING/LOCATING DEVICE
SAR	90	ALERTING AND LOCATING SYSTEMS	DETECT	019	ALERTING/LOCATING AIRBORNE SOUND EMISSIONS
SAR	90	ALERTING AND LOCATING SYSTEMS	DETECT	020	ALERTING/LOCATING WATERBORNE SOUND EMISSIONS
SAR	90	ALERTING AND LOCATING SYSTEMS	LOCATE	022	RANGE OR BEARING OF EMITTER
SAR	90	ALERTING AND LOCATING SYSTEMS	LOCATE	023	RANGE AND BEARING OF EMITTER
SAR	90	ALERTING AND LOCATING SYSTEMS	LOCATE	025	GEOGRAPHICAL POSITION OF EMITTER
SAR	90	ALERTING AND LOCATING SYSTEMS	IDENTIFY	026	NAME OR NUMBER OF CALLING UNIT
SAR	90	ALERTING AND LOCATING SYSTEMS	IDENTIFY	029	TYPE OF EMITTER AND CALLING UNIT
SAR	90	ALERTING AND LOCATING SYSTEMS	IDENTIFY	032	FREQUENCY OF ALERTING/LOCATING RADIO SIGNAL
SAR	90	ALERTING AND LOCATING SYSTEMS	IDENTIFY	033	CHARACTERISTIC CODE OF ALERTING/LOCATING SIGNAL
SAR	90	ALERTING AND LOCATING SYSTEMS	OBSERVE	037	MOVEMENT OF CALLING UNIT
SAR	91	SURFACE SEARCH	DETECT	002	LARGE VESSEL
SAR	91	SURFACE SEARCH	DETECT	003	MEDIUM-SIZED VESSEL
SAR	91	SURFACE SEARCH	DETECT	004	SMALL VESSEL, AFLOAT SEAPLANE
SAR	91	SURFACE SEARCH	DETECT	005	MAN IN WATER, DITCHED AIRCRAFT
SAR	91	SURFACE SEARCH	LOCATE	022	RANGE OR BEARING OF SEARCH OBJECT

TABLE 3-4. (Continued).

PROG	PA	PROGRAM ACTIVITY	FUNCTION	SIE	SURVEILLANCE INFORMATION ELEMENT
SAR	91	SURFACE SEARCH	LOCATE	023	RANGE AND BEARING OF SEARCH OBJECT
SAR	91	SURFACE SEARCH	LOCATE	025	GEOGRAPHICAL POSITION OF SEARCH OBJECT
SAR	91	SURFACE SEARCH	IDENTIFY	026	NAME OR NUMBER OF SEARCH OBJECT
SAR	91	SURFACE SEARCH	IDENTIFY	029	TYPE OF SEARCH OBJECT
SAR	91	SURFACE SEARCH	IDENTIFY	030	COLOR OF SEARCH OBJECT
SAR	91	SURFACE SEARCH	IDENTIFY	031	SHAPE (APPEARANCE) OF SEARCH OBJECT
SAR	91	SURFACE SEARCH	OBSERVE	037	MOVEMENT OF SEARCH OBJECT
SAR	91	SURFACE SEARCH	OBSERVE	056	SIZE OF SEARCH OBJECT
SAR	91	SURFACE SEARCH	OBSERVE	067	NATURE OF DISTRESS: DISABLED OR INJURED
SAR	91	SURFACE SEARCH	OBSERVE	068	NATURE OF DISTRESS: AFIRE
SAR	91	SURFACE SEARCH	OBSERVE	069	NATURE OF DISTRESS: SINKING
SAR	91	SURFACE SEARCH	OBSERVE	070	NATURE OF DISTRESS: AGROUND

NOTES FOR CHAPTER 3

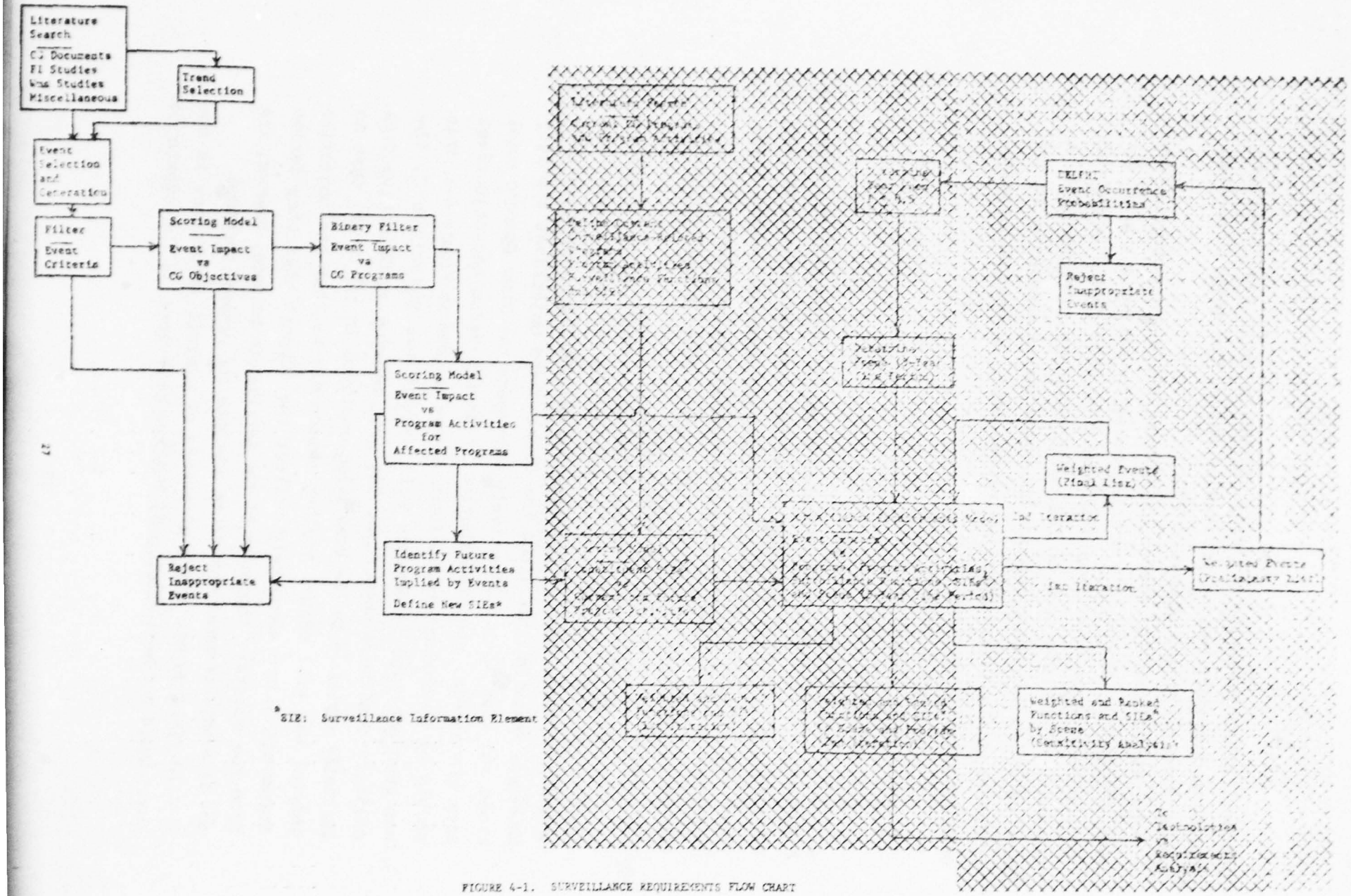
1. Reference 44.
2. Reference 44, Table 3-5.
3. Reference 14.
4. Reference 44, page 2-1.

CHAPTER 4 - FUTURE EVENTS: IMPACT ON THE COAST GUARD

An assessment of future surveillance requirements necessitates a view or construct of what the future holds. Given the present state of the forecasting art, only glimpses of the future are possible. The Commandant's Long Range View[1] and a number of recent independent futures studies[2] performed for the Coast Guard provide the basis for deriving future surveillance requirements. Drawing on these sources, considerable pains have been taken to develop a set of events which, if not exhaustive (an impossible goal), is at least representative of a plausible future. In this chapter the development of a set of events and the impacts of their occurrence is undertaken; timing and probabilities of occurrence are treated in Chapter 5.

The references cited above have been searched in order to develop a set of trends and future events which are relevant to both the Coast Guard and its surveillance requirements. The unshaded portion of Figure 4-1, a flow chart of the process, shows the development beginning at the upper left. Trend information has been filtered and assembled first according to its nature (technological, economic, political, societal, environmental), and then by domain (international, national, marine). The objective has been to produce a set of trends which is broad in nature but focused on the marine domain, since it is in the marine domain that surveillance requirements are generated. A list of trends, with sources cited, is given in Appendix A.

Although the impact of the future on Coast Guard surveillance requirements is treated in the present study in terms of events rather than trends, the trend development is necessary since it provides the background and source of a class of events which may be described as trend thresholds, or points on a trend line. It is also possible to conceive of another class of events: occurrences which are independent of recognized trends, such as accidents or natural disasters. Both classes of events have been included in the selection



*SIE: Surveillance Information Element

FIGURE 4-1. SURVEILLANCE REQUIREMENTS FLOW CHART

process. Event selection criteria, shown in Table 4-1, have been applied as a gross filtering process to reduce the several hundred events contained in the sources to 95.

The significance of events satisfying the event criteria has been assessed by means of a scoring model by asking how much the occurrence of each event would affect the Coast Guard workload necessary to satisfy each of the seven Coast Guard Objectives. A panel of FI staff members has made these estimates according to the following scale (where positive values imply a workload increase, negative values a decrease):

0 - Negligible effect

± 2 - Small effect

± 4 - Moderate effect

± 8 - Major effect

A sample scoring model work form is given in Figure 4-2. The total score for each event is obtained by summing over all objectives the score for each objective times the normalized objective weight, which is a Coast Guard-assigned importance estimate[3]. These totals for all events are then normalized to 1000, i.e., after normalization the total sum of all event scores equals 1000.

The purpose of this scoring model is two-fold: first, to obtain a measure of the importance of each event to the Coast Guard, and second, to assure that a representative set of future events has been obtained. Reasoning that since the Coast Guard Objectives are very broad and that they collectively encompass the Coast Guard's total area of concern, the distribution of scores among the objectives should be approximately uniform. As may be seen in Figure 4-3, this has been achieved reasonably well except for Objective C, the military readiness objective. The poor showing of Objective C is partially explained by the assumption employed in the study that no general war will occur. Another reason may be that the objective statements do not adequately reflect the support that they derive from the military character of the Service. On balance, however, the set of events is considered to be adequate for present purposes.

At this point, a set of events of overall importance to the Coast Guard has been developed, but the relevance of the events to

TABLE 4-1. CRITERIA FOR CHOOSING EVENTS FOR ANALYSIS

1.	TIMELINESS:	THE NEARER THE OCCURRENCE OF THE EVENT, THE MORE IMPORTANT THE EVENT BE INCLUDED.
2.	PROBABILITY:	THE HIGHER THE PROBABILITY OF OCCURRENCE, THE MORE IMPORTANT THE EVENT BE INCLUDED.
3.	IMPORTANCE AS A TREND:	THE MORE DOMINANT AND RELEVANT THE EVENT IS AS AN INDICATOR OF BROAD AND MAJOR SOCIETAL CHANGE, THE MORE IMPORTANT IT IS FOR ANALYSIS.
4.	IMPORTANCE TECHNOLOGICALLY:	THE MORE PROMINENT AND RELEVANT THE EVENT IS AS AN INDICATOR OF MAJOR TECHNOLOGICAL INNOVATION, THE MORE IMPORTANT IT IS FOR ANALYSIS.
5.	PRECISENESS OF EVENT:	THE STATEMENT OF THE EVENT MUST BE SUFFICIENTLY PRECISE TO CONVEY ITS MEANING AND TO ENABLE ITS OCCURRENCE TO BE RECOGNIZED.
6.	RELEVANCE TO MARINE POLICY:	THE MORE RELEVANT THE EVENT IS TO PRESENT AND POTENTIAL MARINE APPLICATIONS, THE MORE IMPORTANT IT IS FOR ANALYSIS.
7.	MAGNITUDE OF IMPACT:	THE GREATER THE LIKELY MAGNITUDE OF THE IMPACT OF THE EVENT ON THE COAST GUARD AND ON COAST GUARD SURVEILLANCE REQUIREMENTS, THE MORE IMPORTANT IT IS FOR ANALYSIS.

EVENT SIGNIFICANCE

Event No. _____ Protocol: How much would the occurrence of this event affect the Coast Guard workload necessary to satisfy Objective __?

EVENT: There will be underwater parks equipped with underwater observation posts, underwater resturants, underwater promenades, underwater monorails, and submarine tourist vessels.

Objective		Score
OBJECTIVE A - (Weight = 30)	To minimize loss of life, personal injury, and property damage on, over, and under the high seas and waters subject to United States' jurisdiction	4 / 120
OBJECTIVE B - (Weight = 15)	To facilitate waterborne activity in support of national economic, scientific defense, and social needs	4 / 60
OBJECTIVE C - (Weight = 10)	To maintain an effective, ready armed force prepared for and immediately responsive to specific tasks in time of war or emergency	0 / 0
OBJECTIVE D - (Weight = 15)	To assure the safety and security of vessels and of ports and waterways and their related shoreside facilities	4 / 60
OBJECTIVE E - (Weight = 15)	To enforce federal laws and international agreements on and under waters subject to the jurisdiction of the United States and on and under the high seas where authorized	2 / 30
OBJECTIVE F - (Weight = 10)	To maintain or improve the quality of the Marine Environment	4 / 40
OBJECTIVE G - (Weight = 5)	To cooperate with other Governmental agencies and entities (Federal, State, and Local) to assure efficient utilization of public resources and to carry out activities in the international sphere where appropriate in furthering national policy	4 / 20
	TOTAL	330

FIGURE 4-2. EVENT SCORING MODEL WORK FORM

CG Objective	A	B	C	D	E	F	G	TOTAL
Number of Scores (2,4,8) Recorded Under Objective	53	53	16	59	52	52	57	342
Percent of Total Number of Scores	15.5%	15.5%	4.7%	17.2%	15.2%	15.2%	16.7%	100.0%

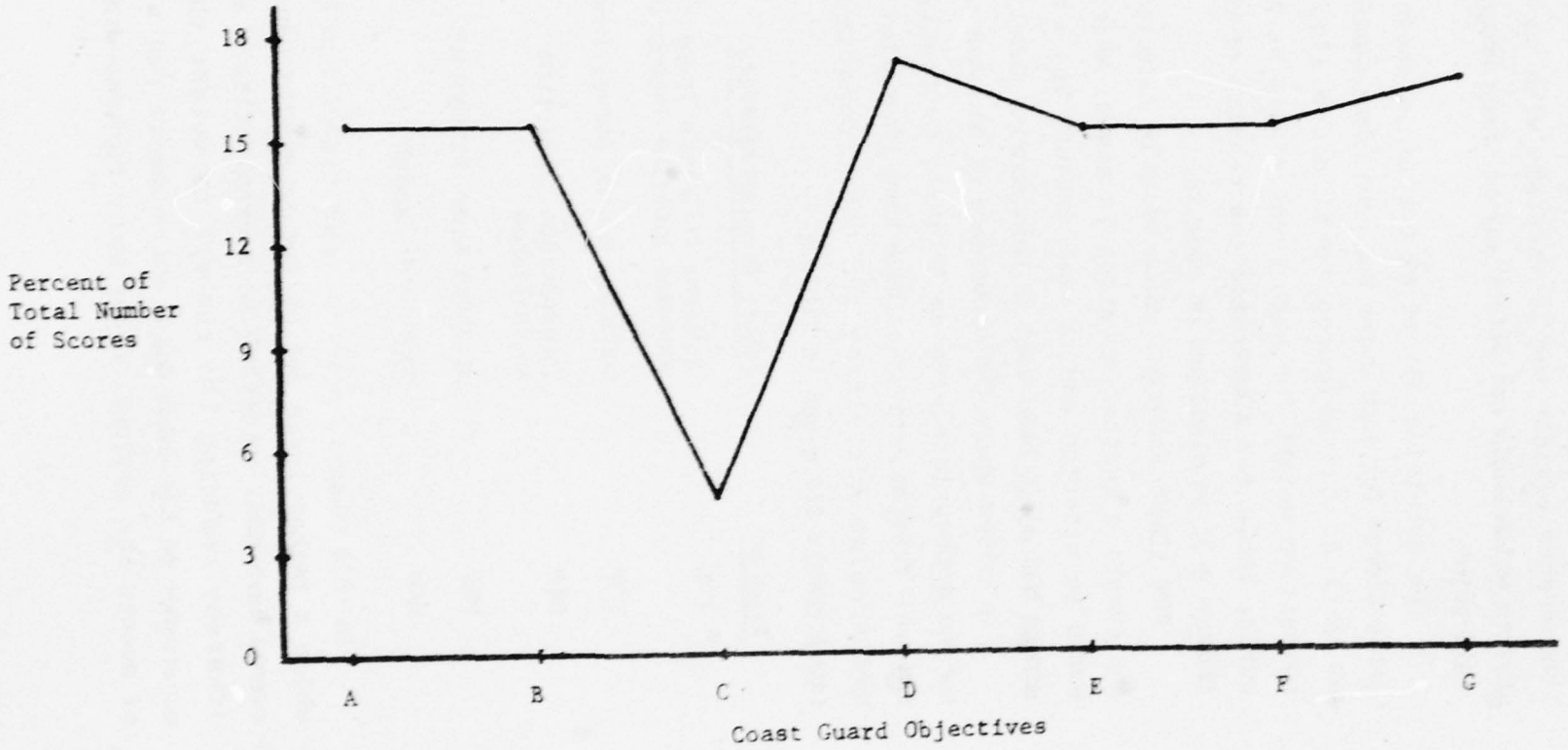


FIGURE 4-3. DISTRIBUTION OF SCORES, EVENTS vs. COAST GUARD OBJECTIVES

Coast Guard surveillance requirements has not yet been established. This has been done in simple binary (yes or no) fashion by arraying the events against the 11 Programs with surveillance requirements. Events which would not affect any of these Programs were rejected at this point.

The surviving set of 62 events is shown in Table 4-2. In this table scores for each event for each Coast Guard Objective are given, as well as the weighted total score ("Total" column) and the normalized weight for each event ("Norm Wt A" column). In other words, Table 4-2 summarizes the results of the Event Scoring Model (Figure 4-2) as discussed on page 28.

For those Programs which would be affected by the occurrence of any event, a further question is asked: Which Program Activities would be affected and to what extent? The $\pm$ 8, $\pm$ 4, $\pm$ 2, 0 scoring scheme has again been used in this scoring model.

In cases where the occurrence of an event would affect a Program but no appropriate Program Activity currently exists, new (i.e., future) Program Activities have been identified and are listed below. New Program Activities and their constituent surveillance requirements are given in Table 4-3.

Program	Future Program Activity	PA Code
CVS	Undersea Structure Inspection	14
	Undersea Pipeline Inspection	15
ELT	Undersea Mining Surveillance	23
MEP	International Pollution Surveillance	42
PSS	Offshore Asset Protection	80
SAR	Underwater Search	92

In this chapter, a set of major trends has been developed from which a rather large set of future events has been derived. These events have been subjected to several filters and a scoring model (thereby reducing the number) to weight the impact of their occurrence on the Coast Guard and to assure that a representative set of events has evolved. Coast Guard Programs which would be affected

TABLE 4-2. PRELIMINARY LIST OF SCORED AND WEIGHTED EVENTS

EVNT NMBR	RANK	EVENT DESCRIPTION	C A	G B	OB C	JE D	CT E	IV F	E G	TOTAL	NORM WT A
0001	31	UNDERWATER PARKS WITH OBSERVATION POSTS, PROMENADES, MONORAILS AND SUBMARINE TOURIST VESSELS	4	4	0	4	2	4	4	330	16
0002	11	PERMANENT UNDERSEA INSTALLATIONS ARE INHABITED	8	4	0	4	2	4	4	450	22
0003	62	EMERGENCY ALERTING & LOCATING DEVICES LEGALLY REQUIRED ON ALL US RECREATIONAL BOATS OVER 25 FT LONG	-8	0	0	2	0	0	2	-200	-9
0004	4	US INTERVENES MILITARILY TO ASSURE FLOW OF RAW MATERIALS (NON-PETROLEUM) FOR US INDUSTRY	8	8	8	8	0	0	8	600	29
0005	62	LOCATING DEVICES ARE REQUIRED TO BE CARRIED ABOARD ALL US & LICENSED FOREIGN FISHING VESSELS IN FCZ	-4	0	0	-2	-8	0	2	-200	-12
0006	58	NUCLEAR-POWERED SHIP SINKS ON OUTER CONTINENTAL SHELF	2	0	0	2	2	4	2	170	8
0007	42	THERE WILL BE MORE THAN 10.5 MILLION PLEASURE BOATS IN THE U.S.	4	4	0	2	2	4	2	290	14
0008	34	TERRORIST GROUP COMANDEERS AND HOLDS FOR RANSOM A FUEL SHIPMENT TO A FLOATING NUCLEAR POWER PLANT	0	4	4	8	4	0	8	320	16
0009	21	MAJOR OIL SPILL FROM A TANKER OCCURS IN LOWER CHESAPEAKE BAY	2	4	0	8	2	8	4	370	18
0010	1	LNG TANKER EXPLODES OFF U.S. EAST COAST	8	8	0	8	4	4	8	620	30
0011	21	TWO TANKERS COLLIDE OFF DELAWARE CAPES	2	4	0	8	2	8	4	370	18
0012	16	TANKER COLLIDES WITH U.S. OIL PLATFORM	2	8	0	8	2	8	4	430	21
0013	45	MAJOR UNDERWATER OIL PIPELINE BREAK OCCURS	0	2	0	8	2	8	4	280	14
0014	20	THREE-SHIP COLLISION OCCURS OFF AMBROSE LIGHT (APPROACHES TO NEW YORK)	4	8	0	4	2	4	4	390	19
0015	21	30% OF DOMESTIC PETROLEUM PRODUCTION COMES FROM OFFSHORE SOURCES	4	4	0	4	2	8	4	370	18
0016	21	DRIFTING BARGE COLLIDES WITH A FLOATING NUCLEAR POWER PLANT IN A GALE	2	2	0	8	4	8	4	370	18
0017	27	MAJOR FIRE OCCURS ON OIL PLATFORM OFF NEW JERSEY	4	0	0	8	2	8	2	360	17
0018	27	U.S. IMPORTS 35% OR MORE OF NEEDED SUPPLIES OF LIQUID HYDROCARBONS	2	4	0	8	2	8	2	360	17
0019	12	200-MILE FISHERIES CONSERVATION ZONE BECOMES A 200-MILE EXCLUSIVE ECONOMIC ZONE	2	4	2	4	8	8	8	440	21
0020	16	MOST PETROLEUM PRODUCTS IMPORTED TO U.S. COME IN SHIPS LARGER THAN 150,000 DWT	4	4	0	8	2	8	4	430	21
0021	27	THE THIRD CIVILIAN SUBMERSIBLE SINKS, MAKING A TOTL OF 15 LIVES LOST IN SUBMERSIBLE ACCIDENTS	8	2	0	4	2	0	0	360	17
0022	21	WORLD PRODUCTION OF MARINE FOOD INCREASES BY 70% OVER 1975 LEVELS	2	4	0	2	8	8	4	370	18
0023	1	U.S. EXERTS MILITARY FORCE IN DEFENSE OF THE PANAMA CANAL	4	8	8	8	8	2	8	620	30
0024	42	U.S. MERCHANT FLEET (5-100 GRT) WILL NUMBER 62,000(20% INCREASE OVER 1975)	4	2	0	4	2	4	2	290	14
0025	1	U.S. INTERVENES MILITARILY TO ASSURE CONTINUOUS FLOW OF PETROLEUM FOR U.S. INDUSTRY	4	8	8	8	8	2	8	620	30
0026	9	WORLDWIDE THERE ARE 25,000 VESSELS LARGER THAN 1000 GROSS TONS, A 23% INCREASE OVER 1975	4	4	0	8	4	8	4	460	22
0027	30	THE GREAT LAKES ARE OPEN FOR INTRA-LAKE SHIPPING 12 MONTHS PER YEAR	4	8	0	4	0	2	4	340	16
0028	47	THE UPPER REACHES OF THE MISSISSIPPI ARE OPEN FOR SHIPPING 12 MONTHS PER YEAR	2	8	0	4	0	2	2	270	13
0029	35	EXPORTS OF U.S. AGRICULTURAL PRODUCTS VIA GREAT LAKES PORTS INCREASES 50% OVER 1975 LEVELS	2	4	0	4	2	8	4	310	15
0030	49	EXPLOITATION & MINING OF WESTERN COAL RESERVES INCREASES GREAT LAKES TRAFFIC BY 10%	2	4	0	4	0	4	2	230	11
0031	21	MARICULTURE ACCOUNTS FOR 10% OF MARINE FOOD TAKEN FROM THE U.S. FISHERIES CONSERVATION ZONE	2	4	0	2	8	8	4	370	18
0032	42	IMPORTS FROM SINO-SOVIET BLOC NATIONS DOUBLE OVER 1975 LEVELS	2	2	4	4	4	2	4	290	14
0033	35	A FLOATING PLANT IS ESTABLISHED TO EXTRACT MINERALS FROM SEA WATER	2	2	0	4	4	8	4	310	15
0034	60	PORT FACILITIES FOR RECEIVING OILY WASTES VIRTUALLY ELIMINATE BILGE & BALLAST PETROLEUM DUMPING	0	0	0	4	0	-4	2	30	1
0035	12	A KELP FARM IS ESTABLISHED OFF THE COAST OF CALIFORNIA	2	4	2	8	4	8	8	440	21
0036	31	TRANSPORTATION OF HAZARDOUS & TOXIC MATERIALS BY WATER INCREASES TO TWICE THE 1975 TONNAGE	0	4	0	8	2	8	8	330	16
0037	12	SEVEN OFFSHORE NUCLEAR POWER PLANTS ARE OPERATIONAL IN U.S. WATERS	2	4	2	8	4	8	8	440	21
0038	31	THERE ARE 7 OCS OIL DRILLING PLATFORMS WITH A TOTAL OF 120 OIL WELLS IN PLACE IN THE GULF OF ALASKA	2	4	2	4	2	8	4	330	16
0039	12	THERE ARE 14 ATLANTIC OCS OIL DRILLING PLATFORMS WITH A TOTAL OF 240 OIL WELLS IN PLACE	4	4	2	4	4	8	8	440	21
0040	38	12 U.S. OCEAN-THERMAL ENERGY PLANTS ARE OPERATIONAL	2	2	2	4	2	8	4	300	15

TABLE 4-2. (Continued).

EVNT NMBR	RANK	EVENT DESCRIPTION	C A	G B	OB C	JE D	CT E	IV F	E G	TOTAL	NORM WT A
0041	49	FISH STOCKS ON THE ATLANTIC OCS ARE REPLETED TO 1960 LEVELS	2	2	0	2	4	4	2	230	11
0042	45	LAW OF THE SEA TREATY IS RATIFIED	0	2	2	2	8	4	8	280	14
0043	5	WARS IN THE WEST (INCLUDING SOUTH & CENTRAL AMERICA) INVOLVE THE U.S.	4	4	8	8	8	4	8	560	28
0044	48	THERE ARE 150 CIVILIAN SUBMERSIBLES IN USE	4	2	0	4	2	0	2	250	12
0045	7	2-, 3-, AND 4-SEATER HOVERCRAFT COMPRISE 10% OF RECREATIONAL BOATS SOLD	8	8	0	4	4	2	2	510	25
0046	52	A LARGE TIDAL POWER PLANT IS IN OPERATION IN THE U.S.	2	2	0	2	0	8	4	220	11
0047	59	COAL AND NUCLEAR PROPULSION PLANTS ARE USED IN 50% OF NEW SHIP CONSTRUCTION WORLD-WIDE	0	0	0	4	2	4	4	150	7
0048	18	U.S. ACTIVITY LEVELS IN POLAR REGIONS, FOR RESEARCH & NATURAL RESOURCE EXPLORATION, TRIPLE OVER 1975	4	4	2	0	6	4	6	400	19
0049	52	THE AVERAGE AMOUNT OF POLLUTANT RELEASED PER TANKER SPILL INCREASES TO 10,000 TONS	0	2	0	4	2	8	4	220	11
0050	9	DEVELOPMENT OF AT LEAST 1 COMMERCIAL SUBMARINE CARGO VESSEL IN THE 10,000 TON CLASS	8	4	0	4	0	8	4	460	22
0051	52	RESPONSIBILITY FOR SECURITY & SAFETY OF UNDERWATER OIL PIPELINES IS ASSIGNED TO THE COAST GUARD	0	0	0	8	4	2	4	220	11
0052	38	THE MEAN SIZE OF CRUDE OIL TANKERS IN USE EXCEEDS 100,000 DWT	2	4	0	4	4	4	4	300	15
0053	49	6 US DEEPWATER PORTS ARE AVAILABLE OFFSHORE TO HANDLE SUPERTANKERS CARRYING PETROLEUM PRODUCTS	2	2	0	4	2	4	2	230	12
0054	8	NEW TECHNOLOGY PERMITS INSTALLATION OF 600-2700 OIL/NATURAL GAS DRILLING PLATFORMS ON THE U.S. OCS	4	4	2	8	4	8	4	460	23
0055	57	TWICE AS MANY LIGHTER-ABOARD SHIPS (LASH) ARE IN USE AS WERE IN 1975	2	2	0	4	2	0	0	160	9
0056	38	ESTABLISHMENT OF TRANSPORTATION SYSTEM USING 1 M DWT TANKERS, SEADEPTHS & OFFSHORE PETROLEUM TANKS	2	4	0	4	2	8	2	300	15
0057	56	AVERAGE SIZE OF OIL-BULK-ORE CARRIERS IN USE EXCEEDS 200,000 DWT	2	2	0	2	2	4	0	190	9
0058	55	OIL DRILLING RIGS ARE ESTABLISHED IN DEPTHS GREATER THAN 400 METERS	2	2	0	2	2	4	2	200	10
0059	38	LARGE AIR CUSHION VEHICLE FREIGHTERS WITH EITHER CHEMICAL OR NUCLEAR POWER CARRY OCEAN-GOING CARGO	2	6	0	4	2	2	2	300	15
0060	18	STABLE OCEAN PLATFORMS ARE USED AS SEA STATIONS FOR AIRPORTS, RESORTS, & SHIPPING TERMINALS	2	4	0	6	4	6	4	400	19
0061	35	HOVERCRAFT ARE USED AS COMMERCIAL FERRIES FOR PASSENGERS & AUTOS IN AT LEAST 5 STATES	4	4	0	4	2	2	4	310	15
0062	5	A TOWED UNDERWATER BULK CARGO VESSEL IS IN OPERATION	8	8	0	6	0	8	4	560	28

TABLE 4-3. FUTURE PROGRAM ACTIVITIES AND SURVEILLANCE REQUIREMENTS

PROG	PA	PROGRAM ACTIVITY	FUNCTION	SIE	SURVEILLANCE INFORMATION ELEMENT
CVS	13	OFFSHORE PLATFORM INSPECTION	LOCATE	023	HORIZONTAL POSITION OF DEFECT IN THE STRUCTURE
CVS	13	OFFSHORE PLATFORM INSPECTION	LOCATE	024	VERTICAL POSITION OF DEFECT IN THE STRUCTURE
CVS	13	OFFSHORE PLATFORM INSPECTION	OBSERVE	034	STRUCTURAL INTEGRITY
CVS	14	UNDERSEA STRUCTURE INSPECTION	LOCATE	023	HORIZONTAL POSITION OF DEFECT IN THE STRUCTURE
CVS	14	UNDERSEA STRUCTURE INSPECTION	LOCATE	024	VERTICAL POSITION OF DEFECT IN THE STRUCTURE
CVS	14	UNDERSEA STRUCTURE INSPECTION	OBSERVE	034	STRUCTURAL INTEGRITY
CVS	15	UNDERSEA PIPELINE INSPECTION	DETECT	013	LIQUID LEAKAGE FROM PIPELINE
CVS	15	UNDERSEA PIPELINE INSPECTION	LOCATE	022	HORIZONTAL POSITION OF DEFECT IN THE PIPELINE
CVS	15	UNDERSEA PIPELINE INSPECTION	LOCATE	025	GEOGRAPHICAL POSITION OF DEFECT
CVS	15	UNDERSEA PIPELINE INSPECTION	OBSERVE	034	STRUCTURAL INTEGRITY OF PIPELINE
ELT	23	UNDERSEA MINING SURVEILLANCE	DETECT	002	LARGE MINING VESSEL OR FLOATING PLANT
ELT	23	UNDERSEA MINING SURVEILLANCE	DETECT	007	SOLID POLLUTANT/EFFLUENT
ELT	23	UNDERSEA MINING SURVEILLANCE	DETECT	011	SEA BOTTOM
ELT	23	UNDERSEA MINING SURVEILLANCE	LOCATE	024	DEPTH CHANGES RESULTING FROM MINING
ELT	23	UNDERSEA MINING SURVEILLANCE	LOCATE	025	GEOGRAPHICAL POSITION OF MINING VESSEL OR FLOATING PLANT
ELT	23	UNDERSEA MINING SURVEILLANCE	IDENTIFY	026	NAME OR NUMBER OF MINING VESSEL OR FLOATING PLANT
ELT	23	UNDERSEA MINING SURVEILLANCE	IDENTIFY	027	NATIONALITY OF MINING VESSEL OR FLOATING PLANT
ELT	23	UNDERSEA MINING SURVEILLANCE	IDENTIFY	029	TYPE OF MINING/MINING FACILITY
ELT	23	UNDERSEA MINING SURVEILLANCE	OBSERVE	037	MOVEMENT OF MINING VESSEL OR FLOATING PLANT
ELT	23	UNDERSEA MINING SURVEILLANCE	OBSERVE	045	SUSPICIOUS ACTIVITY (DISCHARGING POLLUTANTS)
ELT	23	UNDERSEA MINING SURVEILLANCE	OBSERVE	047	HAZARDOUS ACTIVITY
ELT	23	UNDERSEA MINING SURVEILLANCE	OBSERVE	057	AREA COVERED BY EFFLUENT
MEP	40	COASTAL POLLUTION SURVEILLANCE	DETECT	007	SOLID POLLUTANTS
MEP	40	COASTAL POLLUTION SURVEILLANCE	DETECT	014	GASEOUS POLLUTANTS
MEP	40	COASTAL POLLUTION SURVEILLANCE	DETECT	021	NUCLEAR RADIATION
MEP	40	COASTAL POLLUTION SURVEILLANCE	OBSERVE	060	ENVIRONMENTAL SEA TEMPERATURE CHANGES
MEP	40	COASTAL POLLUTION SURVEILLANCE	OBSERVE	061	ENVIRONMENTAL SALINITY CHANGES
MEP	41	HARBOR POLLUTION SURVEILLANCE	DETECT	007	SOLID POLLUTANTS
MEP	41	HARBOR POLLUTION SURVEILLANCE	DETECT	014	GASEOUS POLLUTANTS
MEP	41	HARBOR POLLUTION SURVEILLANCE	DETECT	021	NUCLEAR RADIATION
MEP	41	HARBOR POLLUTION SURVEILLANCE	OBSERVE	060	ENVIRONMENTAL SEA TEMPERATURE CHANGES
MEP	41	HARBOR POLLUTION SURVEILLANCE	OBSERVE	061	ENVIRONMENTAL SALINITY CHANGES
MEP	42	INT'L POLLUTION SURVEILLANCE	DETECT	007	SOLID POLLUTANTS
MEP	42	INT'L POLLUTION SURVEILLANCE	DETECT	014	GASEOUS POLLUTANTS
MEP	42	INT'L POLLUTION SURVEILLANCE	DETECT	021	NUCLEAR RADIATION
MEP	42	INT'L POLLUTION SURVEILLANCE	OBSERVE	060	ENVIRONMENTAL SEA TEMPERATURE CHANGES
MEP	42	INT'L POLLUTION SURVEILLANCE	OBSERVE	061	ENVIRONMENTAL SALINITY CHANGES
PSS	80	OFFSHORE ASSET PROTECTION	DETECT	001	APPROACHING AIRCRAFT
PSS	80	OFFSHORE ASSET PROTECTION	DETECT	003	MEDIUM-SIZED VESSEL
PSS	80	OFFSHORE ASSET PROTECTION	DETECT	004	SMALL VESSEL
PSS	80	OFFSHORE ASSET PROTECTION	DETECT	005	SURFACE SWIMMER
PSS	80	OFFSHORE ASSET PROTECTION	DETECT	006	UNDERWATER SWIMMER
PSS	80	OFFSHORE ASSET PROTECTION	DETECT	009	SMALL SUBMERGED SUBMERSIBLE
PSS	80	OFFSHORE ASSET PROTECTION	LOCATE	023	RANGE AND BEARING OF THREAT
PSS	80	OFFSHORE ASSET PROTECTION	LOCATE	024	DEPTH OF SWIMMER/SUBMERSIBLE
PSS	80	OFFSHORE ASSET PROTECTION	IDENTIFY	026	NAME OR NUMBER OF THREATENING AIRCRAFT/VESSEL/SUBMERSIBLE
PSS	80	OFFSHORE ASSET PROTECTION	IDENTIFY	027	NATIONALITY OF THREATENING AIRCRAFT/VESSEL/SUBMERSIBLE
PSS	80	OFFSHORE ASSET PROTECTION	IDENTIFY	029	TYPE OF THREAT
PSS	80	OFFSHORE ASSET PROTECTION	OBSERVE	037	MOVEMENT OF THREATENING AIRCRAFT/VESSEL/SUBMERSIBLE/SWIMMER
PSS	80	OFFSHORE ASSET PROTECTION	OBSERVE	042	SUSPICIOUS AIRCRAFT/VESSEL/SUBMERSIBLE ACTIVITY
PSS	80	OFFSHORE ASSET PROTECTION	OBSERVE	046	HOSTILE AIRCRAFT/VESSEL/SUBMERSIBLE ACTIVITY
PSS	80	OFFSHORE ASSET PROTECTION	OBSERVE	053	WEAPONS/MUNITIONS CARRIED BY THREATENING AIRCRAFT/VESSEL/SUBMERSIBLE

TABLE 4-3. (Continued).

PROG	PA	PROGRAM ACTIVITY	FUNCTION	SIE	SURVEILLANCE INFORMATION ELEMENT
SAR	92	UNDERWATER SEARCH	DETECT	009	SMALL SUBMERGED SUBMERSIBLE OR SUNKEN VESSEL
SAR	92	UNDERWATER SEARCH	DETECT	020	SOUND EMISSION IN WATER
SAR	92	UNDERWATER SEARCH	LOCATE	023	RANGE AND BEARING OF SUBMERSIBLE
SAR	92	UNDERWATER SEARCH	LOCATE	024	DEPTH OF SUBMERSIBLE
SAR	92	UNDERWATER SEARCH	LOCATE	025	GEOGRAPHICAL POSITION OF SUBMERSIBLE
SAR	92	UNDERWATER SEARCH	IDENTIFY	026	NAME OR NUMBER OF SUBMERSIBLE
SAR	92	UNDERWATER SEARCH	IDENTIFY	029	TYPE OF SUBMERSIBLE
SAR	92	UNDERWATER SEARCH	OBSERVE	037	MOVEMENT OF SUBMERSIBLE
SAR	92	UNDERWATER SEARCH	OBSERVE	067	NATURE OF DISTRESS: DISABLED
SAR	92	UNDERWATER SEARCH	OBSERVE	071	NATURE OF DISTRESS: SUNK

by the occurrence of these events have been identified and event impacts on current and future Program Activities have been assessed. It should be noted that the development thus far has been independent of time, i.e., the occurrence of all events has been presumed.

NOTES FOR CHAPTER 4

1. Reference 42, Enclosure (1).

2. References 4-6, 9-11.

3. Cited in Reference 11, Page 9.

CHAPTER 5 - FUTURE EVENTS: PROBABILITIES OF OCCURRENCE

Development of a set of future events and assessment of their impacts on the Coast Guard has been discussed in Chapter 4 based on the assumption that all events occur. The purpose of Chapter 5 is to describe the means by which this assumption has been relaxed so that time may be introduced into the analysis. Since the goal is a surveillance R&D program phased over the next 25 years, timing considerations are essential to the analysis.

The premise is that the R&D program should be related in time to the emergence of new surveillance requirements which are implied by a set of future events. Furthermore, it is not the occurrence of an event which drives R&D planning, but rather the probability of such occurrence. In other words, the essence of planning is to anticipate and prepare for future eventualities; research and development should begin before the operational need for new systems and equipment becomes acute. Estimates of the probability of occurrence of each of the events are therefore required. A modified Delphic procedure has been employed for this purpose.

Delphi is a name which is applied rather loosely to a group of methods or techniques for eliciting judgments in such a way that systemic biases introduced by psychological factors relating to group behavior are minimized. In a classical Delphi a group of knowledgeable individuals (experts), unknown to each other, are asked (by mail) to respond to a set of questions. After individual responses are tabulated, the group response is displayed and returned to the respondents who are given an opportunity to change their estimates and explain the reasons for their estimates. This process is repeated until successive changes in the group response become insignificant. This usually occurs by the fourth round of interrogations. The process obviates such influences as oratorical salesmanship, specious arguments, and the bandwagon effect. It also

assures that all points of view are heard, and it documents the proceedings in an objective manner. Such a procedure, however, requires time; six months is an absolute minimum and a year is more realistic[1].

Lacking adequate time for a classical Delphi, a modified procedure has been adopted. A conference rather than correspondence has been employed. However, the psychological influences mentioned above, which are inherent in conferences, have largely been avoided by the use of an electronic tallying device called a Consensor. This device, which is briefly described in Appendix C, preserves anonymity in the voting process and permits immediate display of responses to each question posed.

The event list (Table 5-1, which is a rearrangement of Table 4-2) constituted the agenda for the conference. The events were considered by the group in order of their importance to the Coast Guard. The panelists were not told, however, that the listing was in order of importance.

Selection of panelists is an important consideration in the conduct of any Delphic procedure. A review of the event list indicates the following broad areas of concern: marine vessels, offshore development, commerce, energy, and political-international, societal, and environmental matters. Selection of panelists was governed by the following criteria:

- o expertise in one or more of the areas of concern cited above
- o availability in the greater Washington area
- o availability on the date selected for the Delphi conference (December 4, 1978).

Approximately 25 individuals were contacted and agreed to participate in the Delphi. Of these, six could not attend the conference but agreed to participate by mail. Roughly half the panelists were officer and civilian personnel from Coast Guard Headquarters. A list of participants and their affiliations is given in Table 5-2.

Recognizing the need to deal with the probability of occurrence of an event over time, and that only two or three estimates could be

TABLE 5-1. DELPHI EVENT LIST

EVNT NMBR	RANK	EVENT DESCRIPTION	C A	G B	OB C	JE D	CT E	IV F	E G	TOTAL	NORM WT A
0010	1	LNG TANKER EXPLODES OFF U.S. EAST COAST	8	8	0	8	4	4	8	620	30
0023	1	U.S. EXERTS MILITARY FORCE IN DEFENSE OF THE PANAMA CANAL	4	8	8	8	8	2	8	620	30
0025	1	U.S. INTERVENES MILITARILY TO ASSURE CONTINUOUS FLOW OF PETROLEUM FOR U.S. INDUSTRY	4	8	8	8	8	2	8	620	30
0004	4	US INTERVENES MILITARILY TO ASSURE FLOW OF RAW MATERIALS (NON-PETROLEUM) FOR US INDUSTRY	8	8	8	8	0	0	8	600	29
0043	5	WARS IN THE WEST (INCLUDING SOUTH & CENTRAL AMERICA) INVOLVE THE U.S.	4	4	8	8	8	4	8	580	28
0062	5	A TOWED UNDERWATER BULK CARGO VESSEL IS IN OPERATION	8	8	0	8	0	8	4	580	28
0045	7	2-, 3-, AND 4-SEATER HOVERCRAFT COMPRISE 10% OF RECREATIONAL BOATS SOLD	8	8	0	4	4	2	2	510	25
0054	8	NEW TECHNOLOGY PERMITS INSTALLATION OF 800-2700 OIL/NATURAL GAS DRILLING PLATFORMS ON THE U.S. OCS	4	4	2	8	4	8	4	480	23
0026	9	WORLDWIDE THERE ARE 25,000 VESSELS LARGER THAN 1000 GROSS TONS, A 23% INCREASE OVER 1975	4	4	0	8	4	8	4	460	22
0050	9	DEVELOPMENT OF AT LEAST 1 COMMERCIAL SUBMARINE CARGO VESSEL IN THE 10,000 TON CLASS	8	4	0	4	0	8	4	460	22
0002	11	PERMANENT UNDERSEA INSTALLATIONS ARE INHABITED	8	4	0	4	2	4	4	450	22
0019	12	200-MILE FISHERIES CONSERVATION ZONE BECOMES A 200-MILE EXCLUSIVE ECONOMIC ZONE	2	4	2	4	8	8	8	440	21
0035	12	A KELP FARM IS ESTABLISHED OFF THE COAST OF CALIFORNIA	2	4	2	8	4	8	8	440	21
0037	12	SEVEN OFFSHORE NUCLEAR POWER PLANTS ARE OPERATIONAL IN U.S. WATERS	2	4	2	8	4	8	8	440	21
0039	12	THERE ARE 14 ATLANTIC OCS OIL DRILLING PLATFORMS WITH A TOTAL OF 240 OIL WELLS IN PLACE	4	4	2	4	4	8	8	440	21
0012	16	TANKER COLLIDES WITH U.S. OIL PLATFORM	2	8	0	8	2	8	4	430	21
0020	16	MOST PETROLEUM PRODUCTS IMPORTED TO U.S. COME IN SHIPS LARGER THAN 150,000 DWT	4	4	0	8	2	8	4	430	21
0048	18	U.S. ACTIVITY LEVELS IN POLAR REGIONS, FOR RESEARCH & NATURAL RESOURCE EXPLORATION, TRIPLE OVER 1975	4	4	2	0	8	4	8	400	19
0060	18	STABLE OCEAN PLATFORMS ARE USED AS SEA STATIONS FOR AIRPORTS, RESORTS, & SHIPPING TERMINALS	2	4	0	8	4	8	4	400	19
0014	20	THREE-SHIP COLLISION OCCURS OFF AMBROSE LIGHT (APPROACHES TO NEW YORK)	4	8	0	4	2	4	4	390	19
0009	21	MAJOR OIL SPILL FROM A TANKER OCCURS IN LOWER CHESAPEAKE BAY	2	4	0	8	2	8	4	370	18
0011	21	TWO TANKERS COLLIDE OFF DELAWARE CAPES	2	4	0	8	2	8	4	370	18
0015	21	30% OF DOMESTIC PETROLEUM PRODUCTION COMES FROM OFFSHORE SOURCES	4	4	0	4	2	8	4	370	18
0016	21	DRIFTING BARGE COLLIDES WITH A FLOATING NUCLEAR POWER PLANT IN A GALE	2	2	0	8	4	8	4	370	18
0022	21	WORLD PRODUCTION OF MARINE FOOD INCREASES BY 70% OVER 1975 LEVELS	2	4	0	2	8	8	4	370	18
0031	21	MARICULTURE ACCOUNTS FOR 10% OF MARINE FOOD TAKEN FROM THE U.S. FISHERIES CONSERVATION ZONE	2	4	0	2	8	8	4	370	18
0017	27	MAJOR FIRE OCCURS ON OIL PLATFORM OFF NEW JERSEY	4	0	0	8	2	8	2	360	17
0018	27	U.S. IMPORTS 35% OR MORE OF NEEDED SUPPLIES OF LIQUID HYDROCARBONS	2	4	0	8	2	8	2	360	17
0021	27	THE THIRD CIVILIAN SUBMERSIBLE SINKS, MAKING A TOTL OF 15 LIVES LOST IN SUBMERSIBLE ACCIDENTS	8	2	0	4	2	0	0	360	17
0027	30	THE GREAT LAKES ARE OPEN FOR INTRA-LAKE SHIPPING 12 MONTHS PER YEAR	4	8	0	4	0	2	4	340	16
0001	31	UNDERWATER PARKS WITH OBSERVATION POSTS, PROMENADES, MONORAILS AND SUBMARINE TOURIST VESSELS	4	4	0	4	2	4	4	330	16
0036	31	TRANSPORTATION OF HAZARDOUS & TOXIC MATERIALS BY WATER INCREASES TO TWICE THE 1975 TONNAGE	0	4	0	8	2	8	8	330	16
0038	31	THERE ARE 7 OCS OIL DRILLING PLATFORMS WITH A TOTAL OF 120 OIL WELLS IN PLACE IN THE GULF OF ALASKA	2	4	2	4	2	8	4	330	16
0008	34	TERRORIST GROUP COMMANDEERS AND HOLDS FOR RANSOM A FUEL SHIPMENT TO A FLOATING NUCLEAR POWER PLANT	0	4	4	8	4	0	8	320	16
0029	35	EXPORTS OF U.S. AGRICULTURAL PRODUCTS VIA GREAT LAKES PORTS INCREASES 50% OVER 1975 LEVELS	2	4	0	4	2	8	4	310	15
0033	35	A FLOATING PLANT IS ESTABLISHED TO EXTRACT MINERALS FROM SEA WATER	2	2	0	4	4	8	4	310	15
0061	35	HOVERCRAFT ARE USED AS COMMERCIAL FERRIES FOR PASSENGERS & AUTOS IN AT LEAST 5 STATES	4	4	0	4	2	2	4	310	15
0040	38	12 U.S. OCEAN-THERMAL ENERGY PLANTS ARE OPERATIONAL	2	2	2	4	2	8	4	300	15
0052	38	THE MEAN SIZE OF CRUDE OIL TANKERS IN USE EXCEEDS 100,000 DWT	2	4	0	4	4	4	4	300	15
0056	38	ESTABLISHMENT OF TRANSPORTATION SYSTEM USING 1 M DWT TANKERS, SEABERTHS & OFFSHORE PETROLEUM TANKS	2	4	0	4	2	8	2	300	15

TABLE 5-1. (Continued).

EVNT NMBR	RANK	EVENT DESCRIPTION	C A	G B	OB C	JE D	CT E	IV F	E G	TOTAL	NORM WT A
0059	38	LARGE AIR CUSHION VEHICLE FREIGHTERS WITH EITHER CHEMICAL OR NUCLEAR POWER CARRY OCEAN-GOING CARGO	2	8	0	4	2	2	2	300	15
0007	42	THERE WILL BE MORE THAN 10.5 MILLION PLEASURE BOATS IN THE U.S.	4	4	0	2	2	4	2	290	14
0024	42	U.S. MERCHANT FLEET (5-100 GRT) WILL NUMBER 62,000(20% INCREASE OVER 1975)	4	2	0	4	2	4	2	290	14
0032	42	IMPORTS FROM SINO-SOVIET BLOC NATIONS DOUBLE OVER 1975 LEVELS	2	2	4	4	4	2	4	290	14
0013	45	MAJOR UNDERWATER OIL PIPELINE BREAK OCCURS	0	2	0	8	2	8	4	280	14
0042	45	LAW OF THE SEA TREATY IS RATIFIED	0	2	2	2	6	4	6	280	14
0026	47	THE UPPER REACHES OF THE MISSISSIPPI ARE OPEN FOR SHIPPING 12 MONTHS PER YEAR	2	8	0	4	0	2	2	270	13
0044	48	THERE ARE 150 CIVILIAN SUBMERSIBLES IN USE	4	2	0	4	2	0	2	250	12
0039	49	EXPLOITATION & MINING OF WESTERN COAL RESERVES INCREASES GREAT LAKES TRAFFIC BY 10%	2	4	0	4	0	4	2	230	11
0041	49	FISH STOCKS ON THE ATLANTIC OCS ARE REPLETED TO 1960 LEVELS	2	2	0	2	4	4	2	230	11
0053	49	6 US DEEPWATER PORTS ARE AVAILABLE OFFSHORE TO HANDLE SUPERTANKERS CARRYING PETROLEUM PRODUCTS	2	2	0	4	2	4	2	230	11
0046	52	A LARGE TIDAL POWER PLANT IS IN OPERATION IN THE U.S.	2	2	0	2	0	8	4	220	11
0049	52	THE AVERAGE AMOUNT OF POLLUTANT RELEASED PER TANKER SPILL INCREASES TO 10,000 TONS	0	2	0	4	2	8	4	220	11
0051	52	RESPONSIBILITY FOR SECURITY & SAFETY OF UNDERWATER OIL PIPELINES IS ASSIGNED TO THE COAST GUARD	0	0	0	8	4	2	4	220	11
0058	55	OIL DRILLING RIGS ARE ESTABLISHED IN DEPTHS GREATER THAN 400 METERS	2	2	0	2	2	4	2	200	10
0057	56	AVERAGE SIZE OF OIL-BULK-ORE CARRIERS IN USE EXCEEDS 200,000 DWT	2	2	0	2	2	4	0	190	9
0055	57	TWICE AS MANY LIGHTER-ABOARD SHIPS (LASH) ARE IN USE AS WERE IN 1975	2	2	0	4	2	0	0	180	9
0006	58	NUCLEAR-POWERED SHIP SINKS ON OUTER CONTINENTAL SHELF	2	0	0	2	2	4	2	170	8
0047	59	COAL AND NUCLEAR PROPULSION PLANTS ARE USED IN 50% OF NEW SHIP CONSTRUCTION WORLD-WIDE	0	0	0	4	2	4	4	150	7
0034	60	PORT FACILITIES FOR RECEIVING OILY WASTES VIRTUALLY ELIMINATE BILGE & BALLAST PETROLEUM DUMPING	0	0	0	4	0	-4	2	30	1
0003	61	EMERGENCY ALERTING & LOCATING DEVICES LEGALLY REQUIRED ON ALL US RECREATIONAL BOATS OVER 25 FT LONG	-8	0	0	2	0	0	2	-200	-9
0005	62	LOCATING DEVICES ARE REQUIRED TO BE CARRIED ABOARD ALL US & LICENSED FOREIGN FISHING VESSELS IN FCZ	-4	0	0	-2	-8	0	2	-200	-12

TABLE 5-2. DELPHI PARTICIPANTS

Coast Guard Headquarters	
Office of the Chief of Staff	Mr. Alvin Temin Plans Evaluation Division
Office of Public and International Affairs	Mr. Gerard P. Yoest International Affairs Division
Office of Boating Safety	Capt. J. E. Coulter Technical Division
Office of Research and Development	Capt. R. T. Platt, Jr. Deputy Office Chief
	Mr. Lawrence Nivert Mr. Douglas G. Conley Lt. Thomas S. Marhevko Safety and Advanced Technology Division
Office of Merchant Marine Safety	Cdr. G. Barton Technical Division
Office of Operations	Cdr. L. E. Telfer Ocean Operations Division
Office of Marine Environment and Systems	Capt. G. P. Sherburne Deep Water Ports Project
	Cdr. R. S. Palmer, Jr. Marine Environmental Protection Division
	Capt. D. B. Charter Port Safety and Law Enforcement Division
Department of Commerce	
Maritime Administration	Mr. Virgil W. Rinehart Office of Maritime Technology
	Mr. James Gross Office of Advanced Ships Operation
Library of Congress	Mr. Walter Hahn Congressional Research Service
Charles W. Williams, Inc.	Dr. Kenneth Simmons
U. S. Congress	Dr. Tom Cotton* Office of Technology Assessment

*Mail participants.

Table 5-2 (Continued)

Department of Energy	Dr. Melvin Chiogioji* Division of Buildings and Community Systems
	Dr. Paul Lefcourt Energy Coordination Staff
Forecasting International, Ltd.	Dr. Marvin J. Cetron
	Mr. Charles F. McFadden
	Ms. Sharon E. Sugarek
	Dr. Anne Nelsen
	Ms. Ethelyn Bishop
	Ms. Marge Freese

*Mail participants.

obtained for each event, the cumulative distribution function, rather than the density function, was selected as the basis for Delphi questioning. Because the cumulative distribution function increases monotonically from 0 to 1, two or three points enable its shape to be estimated. As may be seen in Figure 5-1, two or three points permit no such approximation of the shape of the density function. The question posed to the panelists was therefore:

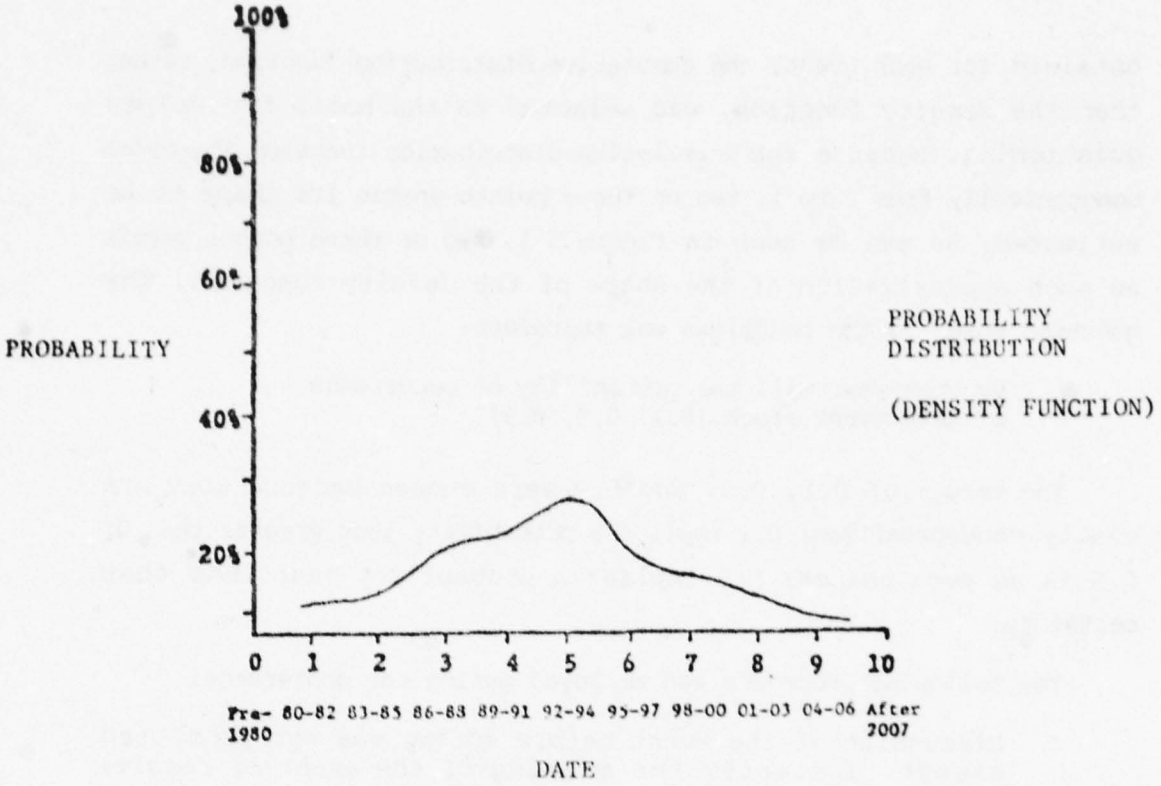
> By what year will the probability of occurrence of this event reach (0.1, 0.5, 0.9)?

The values of 0.1, 0.5, and 0.9 were chosen because they are easily conceptualized; 0.1 implies a probability just greater than 0; 0.5 is an even chance; 0.9 implies a probability just less than certainty.

The following procedure was employed during the conference:

- Discussion of the event before voting was not permitted except to clarify the meaning of the event or resolve semantical problems.
- Three votes were taken in succession for each event, i.e., an estimate was requested for each of the probability levels.
- If, in the judgment of the moderator, the group's responses represented a reasonable consensus, attention moved to the next event; if not, a brief discussion was opened to clarify the panelists' positions, followed by a re-vote at all three probability levels.

The results of the Delphi are given in detail in Appendix D and are briefly summarized here. Of the 62 events considered, 16 descriptions were altered during the conference and three events were deleted. One additional event was framed at the conference. Mail responses by three participants (of the six promised) were later combined with the conference responses for events which were not altered in the course of the conference. It has been possible to approximate the cumulative distribution function for each event. Although responses at some probability levels are bimodal (even after discussion and a second vote in some cases) or relatively flat, most group responses approximated a normal distribution sufficiently well to indicate a usable consensus.



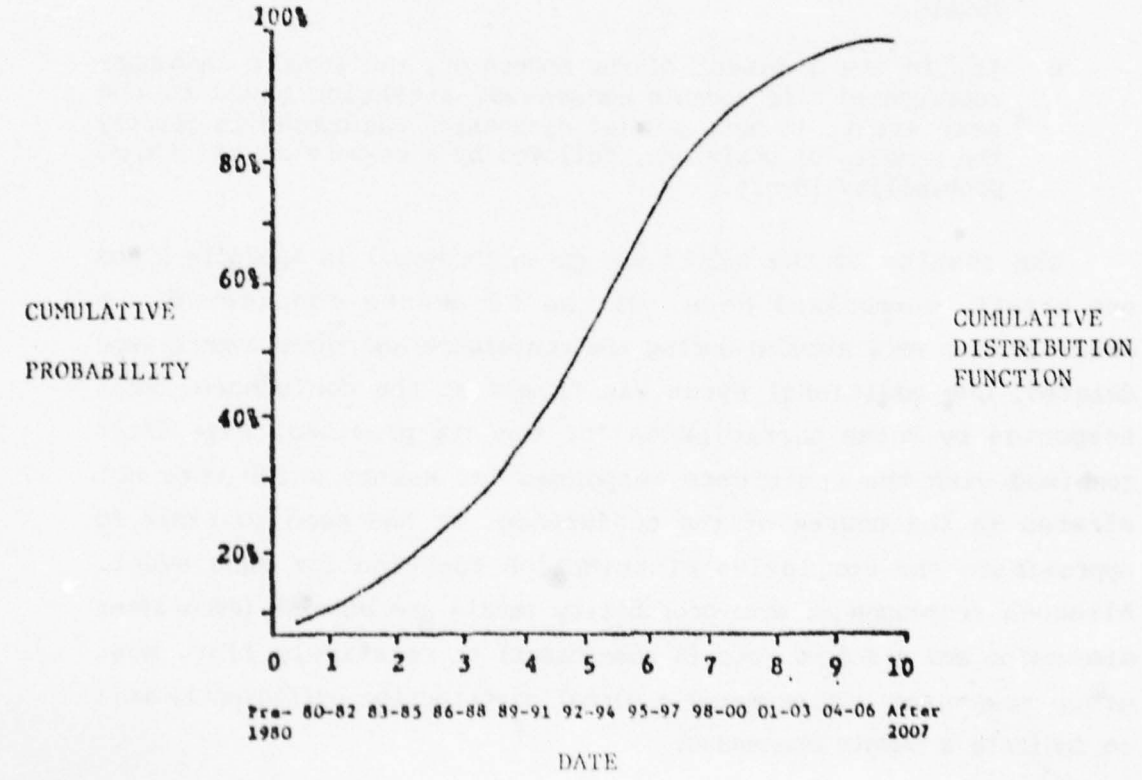


FIGURE 5-1. GRAPHS OF DISTRIBUTION FUNCTIONS

Any lack of precision tends to be mitigated because time periods of three years have been used for the Delphi estimates, whereas the study is concerned with larger (5-year) intervals. In order to permit phasing surveillance requirements over the next 25 years, 5-year intervals, termed "scenes," have been defined as follows:

Scene	5-Year Interval
1	1980-1984
2	1985-1989
3	1990-1994
4	1995-1999
5	2000-2004

The results of the Delphi cconference are summarized in Tables 5-3 and 5-4. Table 5-3, the final list of 60 events, is a revision of Table 5-1 which incorporates changes, additions and deletions resulting from the conference; Table 5-4 shows, in addition to the ranked and weighted importance of each event to the Coast Guard, the dates by which the probability of occurrence is estimated to reach the three probability levels addressed in the Delphi conference. A trigger date (an estimate of the year in which the probability of occurrence will reach 0.5) is also shown.

TABLE 5-3. FINAL EVENT LIST

EVNT NMBR	RANK	EVENT DESCRIPTION	C A	G B	OB C	JE D	CT E	IV F	E G	TOTAL	NORM WT A
0019	1	LNG TANKER EXPLODES OFF U.S. EAST COAST	8	8	0	8	4	4	8	620	31
0023	1	U.S. EXERTS MILITARY FORCE IN DEFENSE OF THE PANAMA CANAL	4	8	8	8	8	2	8	620	31
0025	1	U.S. INTERVENES MILITARILY TO ASSURE CONTINUOUS FLOW OF PETROLEUM FOR U.S. INDUSTRY	4	8	6	8	8	2	8	620	31
0004	4	US INTERVENES MILITARILY TO ASSURE FLOW OF RAW MATERIALS (NON-PETROLEUM) FOR US INDUSTRY	8	8	8	8	0	0	8	600	30
0030	5	A TOWED UNDERWATER BULK CARGO VESSEL IS IN OPERATION	8	8	0	8	0	8	4	580	29
0043	5	WARS IN THE WEST (INCLUDING SOUTH & CENTRAL AMERICA) INVOLVE THE U.S.	4	4	8	8	8	4	8	580	29
0045	7	2-, 3-, AND 4-SEATER HOVERCRAFT COMPRISE 10% OF RECREATIONAL BOATS SOLD	8	8	0	4	4	2	2	510	25
0018	8	COAST GUARD IS ASSIGNED PEACETIME FEDERAL OCS ASSET SECURITY RESPONSIBILITY OUTSIDE TERRITORIAL SEA	4	2	8	8	8	0	4	490	24
0054	9	INSTALLATION OF 800-2700 MORE OIL/NATURAL GAS DRILLING OR PRODUCTION PLATFORMS ON THE U.S. OCS	4	4	2	8	4	8	4	480	24
0026	10	WORLDWIDE THERE ARE 25,000 VESSELS LARGER THAN 1000 GROSS TONS, A 23% INCREASE OVER 1975	4	4	0	8	4	8	4	460	23
0050	10	DEVELOPMENT OF AT LEAST 1 COMMERCIAL SUBMARINE CARGO VESSEL IN THE 10,000 TON CLASS	8	4	0	4	0	8	4	460	23
0002	12	PERMANENT UNDERSEA INSTALLATIONS ARE MANNED CONTINUOUSLY FOR COMMERCIAL ACTIVITY	8	4	0	4	2	4	4	450	22
0019	13	200-MILE FISHERIES CONSERVATION ZONE BECOMES A 200-MILE EXCLUSIVE ECONOMIC ZONE	2	4	2	4	8	8	8	440	22
0035	13	A KELP FARM IS ESTABLISHED OFF THE COAST OF CALIFORNIA	2	4	2	8	4	8	8	440	22
0037	13	SEVEN OFFSHORE NUCLEAR POWER PLANTS ARE OPERATIONAL IN U.S. WATERS	2	4	2	8	4	8	8	440	22
0039	13	THERE ARE 14 ATLANTIC OCS OIL DRILLING PLATFORMS WITH A TOTAL OF 240 OIL WELLS IN PLACE	4	4	2	4	4	8	8	440	22
0012	17	TANKER COLLIDES WITH U.S. OIL PLATFORM	2	8	0	8	2	8	4	430	21
0020	17	MOST PETROLEUM (CRUDE & PRODUCTS) IMPORTED TO U.S. COMES IN SHIPS LARGER THAN 150,000 DWT	4	4	0	8	2	8	4	430	21
0048	19	U.S. ACTIVITY LEVELS IN POLAR REGIONS, FOR RESEARCH & NATURAL RESOURCE EXPLORATION, TRIPLE OVER 1975	4	4	2	0	8	4	8	400	20
0060	19	STABLE U.S. OCEAN PLATFORMS ARE USED AS SEA STATIONS FOR AIRPORTS, RESORTS, OR SHIPPING TERMINALS	2	4	0	8	4	8	4	400	20
0014	21	THREE-SHIP COLLISION OCCURS OFF AMBROSE LIGHT (APPROACHES TO NEW YORK)	4	8	0	4	2	4	4	390	19
0009	22	MAJOR OIL SPILL FROM A VESSEL OCCURS IN LOWER CHESAPEAKE BAY	2	4	0	8	2	8	4	370	18
0011	22	TWO TANKERS COLLIDE OFF DELAWARE CAPES	2	4	0	8	2	8	4	370	18
0015	22	30% OF DOMESTIC PETROLEUM PRODUCTION COMES FROM OFFSHORE SOURCES	4	4	0	4	2	8	4	370	18
0016	22	DRIFTING BARGE COLLIDES WITH A FLOATING NUCLEAR POWER PLANT	2	2	0	8	4	8	4	370	18
0022	22	WORLD PRODUCTION OF MARINE FOOD INCREASES BY 70% OVER 1975 LEVELS	2	4	0	2	8	8	4	370	18
0031	22	MARICULTURE ACCOUNTS FOR 10% OF MARINE FOOD TAKEN FROM THE U.S. FISHERIES CONSERVATION ZONE	2	4	0	2	8	8	4	370	18
0017	28	MAJOR FIRE OCCURS ON OIL PLATFORM OFF NEW JERSEY	4	0	0	8	2	8	2	360	18
0021	28	THE THIRD CIVILIAN SUBMERSIBLE SINKS, MAKING A TOTAL OF 15 LIVES LOST IN SUBMERSIBLE ACCIDENTS	8	2	0	4	2	0	0	360	18
0027	30	THE GREAT LAKES ARE OPEN FOR INTRA-LAKE SHIPPING 12 MONTHS PER YEAR	4	8	0	4	0	2	4	340	17
0001	31	UNDERWATER PARKS WITH OBSERVATION POSTS, PROMENADES, MONORAILS AND SUBMARINE TOURIST VESSELS	4	4	0	4	2	4	4	330	16
0036	31	TRANSPORTATION OF HAZARDOUS & TOXIC MATERIALS BY WATER INCREASES TO TWICE THE 1975 TONNAGE	0	4	0	8	2	8	8	330	16
0038	31	THERE ARE 7 OCS OIL DRILLING PLATFORMS WITH A TOTAL OF 120 OIL WELLS IN PLACE IN THE GULF OF ALASKA	2	4	2	4	2	8	4	330	16
0008	34	TERRORIST GROUP COMMANDEERS AND HOLDS FOR RANSOM A FUEL SHIPMENT TO A FLOATING NUCLEAR POWER PLANT	0	4	4	8	4	0	8	320	16
0029	35	EXPORTS OF U.S. AGRICULTURAL PRODUCTS VIA GREAT LAKES PORTS INCREASES 50% OVER 1975 LEVELS	2	4	0	4	2	8	4	310	15
0033	35	A U.S. FLOATING PLANT IS ESTABLISHED TO EXTRACT MINERALS FROM SEA WATER	2	2	0	4	4	8	4	310	15
0049	35	HOVERCRAFT ARE USED AS COMMERCIAL FERRIES FOR PASSENGERS AND AUTOS IN AT LEAST 5 STATES	4	4	0	4	2	2	4	310	15
0040	38	12 U.S. OCEAN-THERMAL ENERGY PLANTS ARE OPERATIONAL	2	2	2	4	2	8	4	300	15
0052	38	THE MEAN SIZE OF CRUDE OIL TANKERS IN USE EXCEEDS 100,000 DWT	2	4	0	4	4	4	4	300	15
0056	38	ESTABLISHMENT OF TRANSPORTATION SYSTEM USING 1 M DWT TANKERS, SEABERTHS & OFFSHORE PETROLEUM TANKS	2	4	0	4	2	8	2	300	15
0059	38	LARGE AIR CUSHION VEHICLE FREIGHTERS WITH EITHER CHEMICAL OR NUCLEAR POWER CARRY OCEAN-GOING CARGO	2	8	0	4	2	2	2	300	15
0007	42	THERE WILL BE MORE THAN 15 MILLION PLEASURE BOATS IN THE U.S.	4	4	0	2	2	4	2	290	14
0024	42	U.S. MERCHANT FLEET (LARGER THAN 5 GRT) WILL NUMBER 62,000 (20% INCREASE OVER 1975)	4	2	0	4	2	4	2	290	14
0032	42	IMPORTS FROM SINO-SOVIET BLOC NATIONS DOUBLE OVER 1975 LEVELS	2	2	4	4	4	2	4	290	14
0013	45	MAJOR UNDERWATER OIL PIPELINE BREAK OCCURS	0	2	0	8	2	8	4	280	14
0042	45	LAW OF THE SEA TREATY IS RATIFIED	0	2	2	2	8	4	8	280	14

TABLE 5-3. (Continued).

EVNT NMBR	RANK	EVENT DESCRIPTION	C A	G B	OB C	JE D	CT E	IV F	E G	TOTAL	NORM WT A
0028	47	THE UPPER REACHES OF THE MISSISSIPPI ARE OPEN FOR SHIPPING 12 MONTHS PER YEAR	2	8	0	4	0	2	2	270	13
0044	48	THERE ARE 150 CIVILIAN SUBMERSIBLES IN USE IN U. S. WATERS	4	2	0	4	2	0	2	250	12
0041	49	FISH STOCKS ON THE ATLANTIC OCS ARE REPLETED TO 1960 LEVELS	2	2	0	2	4	4	2	230	11
0053	49	6 U.S. DEEPWATER PORTS ARE AVAILABLE TO HANDLE SUPERTANKERS CARRYING PETROLEUM (CRUDE & PRODUCTS)	2	2	0	4	2	4	2	230	11
0046	51	A LARGE TIDAL POWER PLANT IS IN OPERATION IN THE U.S.	2	2	0	2	0	6	4	220	11
0051	51	REGULATORY RESPONSIBILITY FOR SECURITY OF UNDERWATER OIL PIPELINES IS ASSIGNED TO THE COAST GUARD	0	0	0	8	4	2	4	220	11
0058	53	OIL DRILLING RIGS ARE ESTABLISHED IN DEPTHS GREATER THAN 400 METERS	2	2	0	2	2	4	2	200	10
0057	54	AVERAGE SIZE OF OIL-BULK-ORE CARRIERS IN USE EXCEEDS 200,000 DWT	2	2	0	2	2	4	0	190	9
0055	55	TWICE AS MANY LIGHTER-ABOARD SHIPS (LASH) ARE IN USE AS WERE IN 1975	2	2	0	4	2	0	0	180	9
0006	56	NUCLEAR-POWERED SHIP SINKS ON OUTER CONTINENTAL SHELF	2	0	0	2	2	4	2	170	8
0047	57	COAL AND NUCLEAR PROPULSION PLANTS ARE USED IN 50% OF NEW SHIP CONSTRUCTION WORLD-WIDE	0	0	0	4	2	4	4	150	7
0034	58	BILGE AND BALLAST PETROLEUM DUMPING IS VIRTUALLY ELIMINATED	0	0	0	4	0	-4	2	30	1
0003	59	EMERGENCY ALERTING & LOCATING DEVICES LEGALLY REQUIRED ON ALL US RECREATIONAL BOATS OVER 25 FT LONG	-8	0	0	2	0	0	2	-200	-9
0005	60	LOCATING DEVICES ARE REQUIRED TO BE CARRIED ABOARD ALL US & LICENSED FOREIGN FISHING VESSELS IN PCZ	-4	0	0	-2	-8	0	2	-260	-12

TABLE 5-4. SUMMARY OF DELPHI RESULTS

EVNT	EVENT DESCRIPTION	INIT WT.A	IAL RANK	CUM.P (0.1)	ROB.D (0.5)	ATES (0.9)	TRIG DATE
0010	LNG TANKER EXPLODES OFF U.S. EAST COAST	31	1	83-85	89-91	98-00	1990
0023	U.S. EXERTS MILITARY FORCE IN DEFENSE OF THE PANAMA CANAL	31	1	89-91	95-97	01-03	1996
0025	U.S. INTERVENES MILITARILY TO ASSURE CONTINUOUS FLOW OF PETROLEUM FOR U.S. INDUSTRY	31	1	86-88	92-94	98-00	1992
0004	US INTERVENES MILITARILY TO ASSURE FLOW OF RAW MATERIALS (NON-PETROLEUM) FOR US INDUSTRY	30	4	89-91	95-97	01-03	1997
0030	A TOWED UNDERWATER BULK CARGO VESSEL IS IN OPERATION	29	5	86-88	92-94	98-00	1993
0043	WARS IN THE WEST (INCLUDING SOUTH & CENTRAL AMERICA) INVOLVE THE U.S.	29	5	86-88	92-94	98-00	1994
0045	2-, 3-, AND 4-SEATER HOVERCRAFT COMPRISE 10% OF RECREATIONAL BOATS SOLD	25	7	86-88	95-97	98-00	1995
0018	COAST GUARD IS ASSIGNED PEACETIME FEDERAL OCS ASSET SECURITY RESPONSIBILITY OUTSIDE TERRITORIAL SEA	24	8	86-88	89-91	92-94	1989
0054	INSTALLATION OF 800-2700 MORE OIL/NATURAL GAS DRILLING OR PRODUCTION PLATFORMS ON THE U.S. OCS	24	9	86-88	92-94	95-97	1992
0026	WORLDWIDE THERE ARE 25,000 VESSELS LARGER THAN 1000 GROSS TONS, A 23% INCREASE OVER 1975	23	10	86-88	92-94	98-00	1992
0050	DEVELOPMENT OF AT LEAST 1 COMMERCIAL SUBMARINE CARGO VESSEL IN THE 10,000 TON CLASS	23	10	89-91	98-00	01-03	1998
0002	PERMANENT UNDERSEA INSTALLATIONS ARE MANNED CONTINUOUSLY FOR COMMERCIAL ACTIVITY	22	12	83-85	89-91	95-97	1989
0019	200-MILE FISHERIES CONSERVATION ZONE BECOMES A 200-MILE EXCLUSIVE ECONOMIC ZONE	22	13	80-82	86-88	92-94	1988
0035	A KELP FARM IS ESTABLISHED OFF THE COAST OF CALIFORNIA	22	13	80-82	86-88	89-91	1981
0037	SEVEN OFFSHORE NUCLEAR POWER PLANTS ARE OPERATIONAL IN U.S. WATERS	22	13	92-94	98-00	01-03	1999
0039	THERE ARE 14 ATLANTIC OCS OIL DRILLING PLATFORMS WITH A TOTAL OF 240 OIL WELLS IN PLACE	22	13	86-88	92-94	98-00	1992
0012	TANKER COLLIDES WITH U.S. OIL PLATFORM	21	17	80-82	86-88	92-94	1986
0023	MOST PETROLEUM (CRUDE & PRODUCTS) IMPORTED TO U.S.COMES IN SHIPS LARGER THAN 150,000 DWT	21	17	83-85	89-91	92-94	1989
0048	U.S. ACTIVITY LEVELS IN POLAR REGIONS, FOR RESEARCH & NATURAL RESOURCE EXPLORATION, TRIPLE OVER 1975	20	19	83-85	89-91	95-97	1991
0060	STABLE U.S. OCEAN PLATFORMS ARE USED AS SEA STATIONS FOR AIRPORTS, RESORTS, OR SHIPPING TERMINALS	20	19	86-88	92-94	98-00	1993
0014	THREE-SHIP COLLISION OCCURS OFF AMBROSE LIGHT (APPROACHES TO NEW YORK)	19	21	86-88	92-94	98-00	1992
0009	MAJOR OIL SPILL FROM A VESSEL OCCURS IN LOWER CHESAPEAKE BAY	18	22	80-82	83-85	89-91	1985
0011	TWO TANKERS COLLIDE OFF DELAWARE CAPES	18	22	80-82	86-88	92-94	1986
0015	30% OF DOMESTIC PETROLEUM PRODUCTION COMES FROM OFFSHORE SOURCES	18	22	80-82	83-85	86-88	1985
0016	DRIFTING BARGE COLLIDES WITH A FLOATING NUCLEAR POWER PLANT	18	22	92-94	98-00	04-06	1999
0022	WORLD PRODUCTION OF MARINE FOOD INCREASES BY 70% OVER 1975 LEVELS	18	22	89-91	95-97	01-03	1996
0031	MARICULTURE ACCOUNTS FOR 10% OF MARINE FOOD TAKEN FROM THE U.S. FISHERIES CONSERVATION ZONE	18	22	83-85	92-94	98-00	1992
0017	MAJOR FIRE OCCURS ON OIL PLATFORM OFF NEW JERSEY	18	28	83-85	89-91	92-94	1991
0021	THE THIRD CIVILIAN SUBMERSIBLE SINKS, MAKING A TOTAL OF 15 LIVES LOST IN SUBMERSIBLE ACCIDENTS	18	28	80-82	86-88	89-91	1986
0027	THE GREAT LAKES ARE OPEN FOR INTRA-LAKE SHIPPING 12 MONTHS PER YEAR	17	30	83-85	86-88	92-94	1986
0001	UNDERWATER PARKS WITH OBSERVATION POSTS, PROMENADES, MONORAILS AND SUBMARINE TOURIST VESSELS	16	31	86-88	89-91	95-97	1991
0036	TRANSPORTATION OF HAZARDOUS & TOXIC MATERIALS BY WATER INCREASES TO TWICE THE 1975 TONNAGE	16	31	83-85	86-88	92-94	1988
0038	THERE ARE 7 OCS OIL DRILLING PLATFORMS WITH A TOTAL OF 120 OIL WELLS IN PLACE IN THE GULF OF ALASKA	16	31	86-88	92-94	95-97	1992
0008	TERRORIST GROUP COMANDEERS AND HOLDS FOR RANSOM A FUEL SHIPMENT TO A FLOATING NUCLEAR POWER PLANT	16	34	92-94	98-00	01-03	1999
0029	EXPORTS OF U.S. AGRICULTURAL PRODUCTS VIA GREAT LAKES PORTS INCREASES 50% OVER 1975 LEVELS	15	35	89-91	95-97	01-03	1996
0033	A U.S. FLOATING PLANT IS ESTABLISHED TO EXTRACT MINERALS FROM SEA WATER	15	35	86-88	92-94	98-00	1993
0049	HOVERCRAFT ARE USED AS COMMERCIAL FERRIES FOR PASSENGERS AND AUTOS IN AT LEAST 5 STATES	15	35	83-85	89-91	95-97	1990
0040	12 U.S. OCEAN-THERMAL ENERGY PLANTS ARE OPERATIONAL	15	38	92-94	98-00	04-06	2000
0052	THE MEAN SIZE OF CRUDE OIL TANKERS IN USE EXCEEDS 100,000 DWT	15	38	86-88	92-94	95-97	1992
0056	ESTABLISHMENT OF TRANSPORTATION SYSTEM USING 1 M DWT TANKERS, SEABERTHS & OFFSHORE PETROLEUM TANKS	15	38	92-94	98-00	04-06	2000
0059	LARGE AIR CUSHION VEHICLE FREIGHTERS WITH EITHER CHEMICAL OR NUCLEAR POWER CARRY OCEAN-GOING CARGO	15	38	98-00	01-03	04-06	2003
0007	THERE WILL BE MORE THAN 15 MILLION PLEASURE BOATS IN THE U.S.	14	42	86-88	92-94	95-97	1992
0024	U.S. MERCHANT FLEET (LARGER THAN 5 GRT) WILL NUMBER 62,000 (20% INCREASE OVER 1975)	14	42	83-85	86-88	89-91	1987
0032	IMPORTS FROM SINO-SOVIET BLOC NATIONS DOUBLE OVER 1975 LEVELS	14	42	80-82	86-88	89-91	1986

TABLE 5-4. (Continued).

EVNT	EVENT DESCRIPTION	INIT WT.A	IAL RANK	CUM.P (0.1)	ROB.D (0.5)	ATES (0.9)	TRIG DATE
0013	MAJOR UNDERWATER OIL PIPELINE BREAK OCCURS	14	45	80-82	83-85	86-88	1984
0042	LAW OF THE SEA TREATY IS RATIFIED	14	45	86-88	92-94	95-97	1992
0028	THE UPPER REACHES OF THE MISSISSIPPI ARE OPEN FOR SHIPPING 12 MONTHS PER YEAR	13	47	86-88	92-94	98-00	1993
0044	THERE ARE 150 CIVILIAN SUBMERSIBLES IN USE IN U. S. WATERS	12	48	83-85	89-91	92-94	1989
0041	FISH STOCKS ON THE ATLANTIC OCS ARE REPLETED TO 1960 LEVELS	11	49	89-91	92-94	95-97	1992
0053	6 U.S. DEEPWATER PORTS ARE AVAILABLE TO HANDLE SUPERTANKERS CARRYING PETROLEUM (CRUDE & PRODUCTS)	11	49	89-91	92-94	95-97	1992
0046	A LARGE TIDAL POWER PLANT IS IN OPERATION IN THE U.S.	11	51	92-94	98-00	04-06	1999
0051	REGULATORY RESPONSIBILITY FOR SECURITY OF UNDERWATER OIL PIPELINES IS ASSIGNED TO THE COAST GUARD	11	51	80-82	83-85	89-91	1985
0058	OIL DRILLING RIGS ARE ESTABLISHED IN DEPTHS GREATER THAN 400 METERS	10	53	80-82	83-85	86-88	1984
0057	AVERAGE SIZE OF OIL-BULK-ORE CARRIERS IN USE EXCEEDS 200,000 DWT	9	54	92-94	98-00	04-06	2000
0055	TWICE AS MANY LIGHTER-ABOARD SHIPS (LASH) ARE IN USE AS WERE IN 1975	9	55	86-88	95-97	98-00	1996
0006	NUCLEAR-POWERED SHIP SINKS ON OUTER CONTINENTAL SHELF	8	56	92-94	98-00	04-06	1999
0047	COAL AND NUCLEAR PROPULSION PLANTS ARE USED IN 50% OF NEW SHIP CONSTRUCTION WORLD-WIDE	7	57	89-91	95-97	01-03	1996
0034	BILGE AND BALLAST PETROLEUM DUMPING IS VIRTUALLY ELIMINATED	1	58	86-88	92-94	98-00	1994
0003	EMERGENCY ALERTING & LOCATING DEVICES LEGALLY REQUIRED ON ALL US RECREATIONAL BOATS OVER 25 FT LONG	-9	59	83-85	86-88	92-94	1988
0005	LOCATING DEVICES ARE REQUIRED TO BE CARRIED ABOARD ALL US & LICENSED FOREIGN FISHING VESSELS IN FCZ	-12	60	80-82	86-88	89-91	1986

NOTES FOR CHAPTER 5

1. Reference 2, Page 109.

CHAPTER 6 - THE SURVEILLANCE REQUIREMENTS MODEL

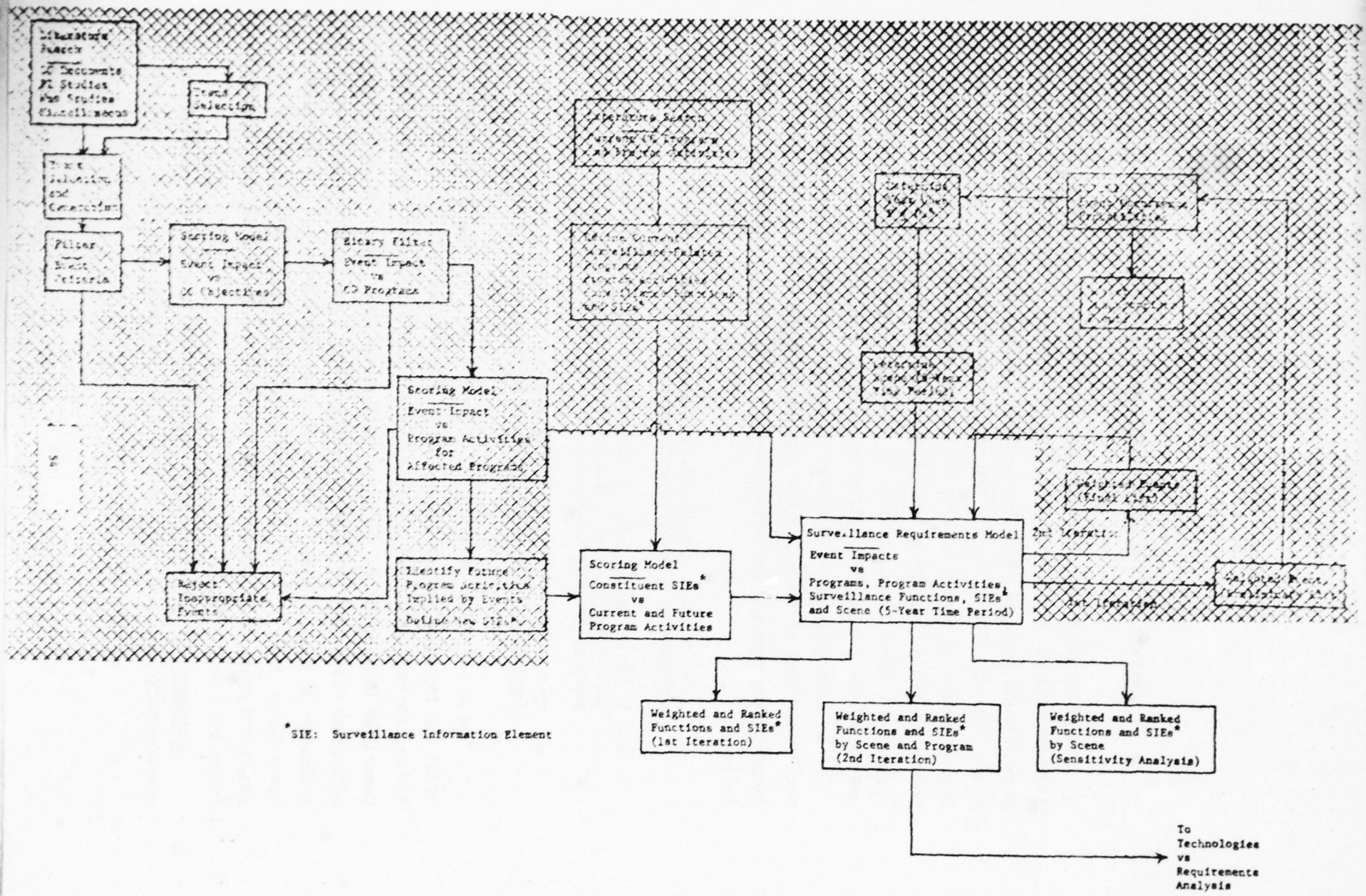
To this point in the analysis, a variety of factors, internal and external to the Coast Guard, which will affect future surveillance requirements, has been evaluated. Current Surveillance Functions and Surveillance Information Elements have been identified and organized in Chapter 3 to serve as a baseline. The future has been characterized by a set of events; Chapter 4 investigated the impacts of their occurrence on the Coast Guard and Chapter 5 addressed their probabilities of occurrence over time.

The next step taken has been to design a model, referred to as the Requirements Model, which incorporates all of these factors in a quantitative manner. The objectives or outputs of the model are as follows:

- Time phased, weighted, and ranked Surveillance Requirements aggregated by Program and overall.
- A final weighting of the events which reflects both their impact on the Coast Guard and their impact on Coast Guard surveillance requirements.
- The means to test the sensitivity of surveillance requirements to event probabilities of occurrence.

The analytical procedure incorporated into the Requirements Model is illustrated in Figure 6-1. Broadly speaking, events are first sorted by scene, (i.e., one of the five-year time periods described in Chapter 5). Then for each scene, the impact of events on affected Programs, Program Activities and Surveillance Functions is assessed. At various points along the way, assessments of importance have been made and weights have been assigned. The scoring and weighting process is described in the following paragraphs and is summarized in Table 6-1.

Assignment of Events to Scenes. The results of the Delphi conference (Chapter 5) have been used to determine the scene to which



*SIE: Surveillance Information Element

FIGURE 6-1. SURVEILLANCE REQUIREMENTS FLOW CHART

TABLE 6-1. SUMMARY OF SCORING AND WEIGHTING PROCESS

	Assigned By	Impacts Scored By	Weighted By	Location in Report: Discussion	Location in Report: Summary
Assignment of Events to Scenes	DELPHI Panel	--	--	Chapter 5 Appendix C	Table 5-4 Appendix D
Event Impacts on CG Objectives	--	FI	Objectives Weighted by USCG[a]	Chapter 4	Table 4-2 Table 5-3
Event Impacts on Operating Programs	--	FI (Binary Only)	Programs Weighted by USCG[b]	Chapter 6	Table 6-3
Event Impacts on Program Activities	--	FI	Program Activities Equally Weighted	Chapter 6	Appendix F
Importance of Surveillance Requirements to Program Activities	--	Not Scored	Requirements Weighted by FI	Chapter 6	Appendix E

[a] cited in reference 11, page 9.

[b] Program Assessment Model, Reference 42, Enclosure (1)

an event belongs. Because R&D planning is anticipatory and there is a time-lag between research and development activities and application in the field, events are assigned to a scene on the premise that an event's implications should become important to R&D planning in the scene immediately prior to the one in which the event's probability of occurrence reaches 0.5 (its trigger date). Trigger dates and scenes which they imply for each event considered are given in Table 6-2 (this is a rearrangement of Table 5-4). For instance, if we examine the second section of Table 6-2, entitled Scene 2: 1985-1989, the first event listed is Event 10: "LNG Tanker explodes off U.S. East Coast." Reading across the line, the trigger date is 1990. Therefore, this event is included in Scene 2: 1985-1989, the scene immediately before the scene which includes the trigger date.

Impact of Events on Coast Guard Objectives. The Coast Guard objectives shape the character of the Service and reflect the major areas of concern. Thus any evaluation of the significance of the impact of events on the Service must consider the relative importance of each objective. As discusssed in Chapter 4, future events have been identified and the effect of their occurrences on Coast Guard Objectives has been assessed.

Coast Guard-assigned Objective weights, which reflect the relative importance the U.S. Coast Guard attaches to each major objective have been used in this assessment. The results of the assessment have been presented in Table 5-3 and may also be seen in Table 6-2, listed in the column titled Initial Wt. A.

Impact of Events on Coast Guard Programs. As is discussed below, for each Coast Guard Program, some 71 potentially applicable Surveillance Information Elements have been identified. Since there are 11 Coast Guard Programs which have surveillance requirements, that implies some 781 potential program-related Surveillance Information Elements. Because the evaluation of the impact of each of the 60-odd events on the 781 potential surveillance requirements would be a monumental task (nearly 47,000 decisions), a screening device has been employed to lessen the task. The screening device (a matrix) has been used to evaluate, on a yes-or-no basis, the impact relationship between the 60 events and the 11 Programs. (Clearly not

TABLE 6-2. FUTURE EVENTS ORGANIZED BY IMPLIED SCENE

IMPLIED SCENE 1 1980-1984

EVNT	EVENT DESCRIPTION	INIT WT.A	IAL RANK	CUM.P (0.1)	ROB.D (0.5)	ATES (0.9)	TRIG DATE	SN
0035	A KELP FARM IS ESTABLISHED OFF THE COAST OF CALIFORNIA	22	13	80-82	86-88	89-91	1981	1
0058	OIL DRILLING RIGS ARE ESTABLISHED IN DEPTHS GREATER THAN 400 METERS	10	53	80-82	83-85	86-88	1984	1
0013	MAJOR UNDERWATER OIL PIPELINE BREAK OCCURS	14	45	80-82	83-85	86-88	1984	1
0015	30% OF DOMESTIC PETROLEUM PRODUCTION COMES FROM OFFSHORE SOURCES	18	22	80-82	83-85	86-88	1985	1
0009	MAJOR OIL SPILL FROM A VESSEL OCCURS IN LOWER CHESAPEAKE BAY	18	22	80-82	83-85	89-91	1985	1
0051	REGULATORY RESPONSIBILITY FOR SECURITY OF UNDERWATER OIL PIPELINES IS ASSIGNED TO THE COAST GUARD	11	51	80-82	83-85	89-91	1985	1
0011	TWO TANKERS COLLIDE OFF DELAWARE CAPES	18	22	80-82	86-88	92-94	1986	1
0012	TANKER COLLIDES WITH U.S. OIL PLATFORM	21	17	80-82	86-88	92-94	1986	1
0032	IMPORTS FROM SINO-SOVIET BLOC NATIONS DOUBLE OVER 1975 LEVELS	14	42	80-82	86-88	89-91	1986	1
0021	THE THIRD CIVILIAN SUBMERSIBLE SINKS, MAKING A TOTAL OF 15 LIVES LOST IN SUBMERSIBLE ACCIDENTS	18	26	80-82	86-88	89-91	1986	1
0005	LOCATING DEVICES ARE REQUIRED TO BE CARRIED ABOARD ALL US & LICENSED FOREIGN FISHING VESSELS IN FCZ	-12	60	80-82	86-88	89-91	1986	1
0024	U.S. MERCHANT FLEET (LARGER THAN 5 GRT) WILL NUMBER 62,000 (20% INCREASE OVER 1975)	14	42	83-85	86-88	89-91	1987	1
0027	THE GREAT LAKES ARE OPEN FOR INTRA-LAKE SHIPPING 12 MONTHS PER YEAR	17	30	83-85	86-88	92-94	1988	1
0019	200-MILE FISHERIES CONSERVATION ZONE BECOMES A 200-MILE EXCLUSIVE ECONOMIC ZONE	22	13	80-82	86-88	92-94	1988	1
0036	TRANSPORTATION OF HAZARDOUS & TOXIC MATERIALS BY WATER INCREASES TO TWICE THE 1975 TONNAGE	16	31	83-85	86-88	92-94	1988	1
0003	EMERGENCY ALERTING & LOCATING DEVICES LEGALLY REQUIRED ON ALL US RECREATIONAL BOATS OVER 25 FT LONG	-9	59	83-85	86-88	92-94	1988	1
0018	COAST GUARD IS ASSIGNED PEACETIME FEDERAL OCS ASSET SECURITY RESPONSIBILITY OUTSIDE TERRITORIAL SEA	24	8	86-88	89-91	92-94	1989	1
0002	PERMANENT UNDERSEA INSTALLATIONS ARE MANNED CONTINUOUSLY FOR COMMERCIAL ACTIVITY	22	12	83-85	89-91	95-97	1989	1
0020	MOST PETROLEUM (CRUDE & PRODUCTS) IMPORTED TO U.S. COMES IN SHIPS LARGER THAN 150,000 DWT	21	17	83-85	89-91	92-94	1989	1
0044	THERE ARE 150 CIVILIAN SUBMERSIBLES IN USE IN U. S. WATERS	12	48	83-85	89-91	92-94	1989	1

IMPLIED SCENE 2 1985-1989

EVNT	EVENT DESCRIPTION	INIT WT.A	IAL RANK	CUM.P (0.1)	ROB.D (0.5)	ATES (0.9)	TRIG DATE	SN
0010	LNG TANKER EXPLODES OFF U.S. EAST COAST	31	1	83-85	89-91	98-00	1990	2
0049	HOVERCRAFT ARE USED AS COMMERCIAL FERRIES FOR PASSENGERS AND AUTOS IN AT LEAST 5 STATES	15	35	83-85	89-91	95-97	1990	2
0048	U.S. ACTIVITY LEVELS IN POLAR REGIONS, FOR RESEARCH & NATURAL RESOURCE EXPLORATION, TRIPLE OVER 1975	20	19	83-85	89-91	95-97	1991	2
0001	UNDERWATER PARKS WITH OBSERVATION POSTS, PROMENADES, MONORAILS AND SUBMARINE TOURIST VESSELS	16	31	86-88	89-91	95-97	1991	2
0017	MAJOR FIRE OCCURS ON OIL PLATFORM OFF NEW JERSEY	18	28	83-85	89-91	92-94	1991	2
0025	U.S. INTERVENES MILITARILY TO ASSURE CONTINUOUS FLOW OF PETROLEUM FOR U.S. INDUSTRY	31	1	86-88	92-94	98-00	1992	2
0053	6 U.S. DEEPWATER PORTS ARE AVAILABLE TO HANDLE SUPERTANKERS CARRYING PETROLEUM (CRUDE & PRODUCTS)	11	49	89-91	92-94	95-97	1992	2
0054	INSTALLATION OF 800-2700 MORE OIL/NATURAL GAS DRILLING OR PRODUCTION PLATFORMS ON THE U.S. OCS	24	9	86-88	92-94	95-97	1992	2
0039	THERE ARE 14 ATLANTIC OCS OIL DRILLING PLATFORMS WITH A TOTAL OF 240 OIL WELLS IN PLACE	22	13	86-88	92-94	98-00	1992	2
0038	THERE ARE 7 OCS OIL DRILLING PLATFORMS WITH A TOTAL OF 120 OIL WELLS IN PLACE IN THE GULF OF ALASKA	16	31	86-88	92-94	95-97	1992	2
0014	THREE-SHIP COLLISION OCCURS OFF AMBROSE LIGHT (APPROACHES TO NEW YORK)	19	21	86-88	92-94	98-00	1992	2
0026	WORLDWIDE THERE ARE 25,000 VESSELS LARGER THAN 1000 GROSS TONS, A 23% INCREASE OVER 1975	23	10	86-88	92-94	98-00	1992	2
0031	MARICULTURE ACCOUNTS FOR 10% OF MARINE FOOD TAKEN FROM THE U.S. FISHERIES CONSERVATION ZONE	16	22	83-85	92-94	98-00	1992	2
0052	THE MEAN SIZE OF CRUDE OIL TANKERS IN USE EXCEEDS 100,000 DWT	15	36	86-88	92-94	95-97	1992	2
0041	FISH STOCKS ON THE ATLANTIC OCS ARE REPLETED TO 1960 LEVELS	11	49	89-91	92-94	95-97	1992	2
0007	THERE WILL BE MORE THAN 15 MILLION PLEASURE BOATS IN THE U.S.	14	42	86-88	92-94	95-97	1992	2
0042	LAW OF THE SEA TREATY IS RATIFIED	14	45	86-88	92-94	95-97	1992	2
0030	A TOWED UNDERWATER BULK CARGO VESSEL IS IN OPERATION	29	5	86-88	92-94	98-00	1993	2
0028	THE UPPER REACHES OF THE MISSISSIPPI ARE OPEN FOR SHIPPING 12 MONTHS PER YEAR	13	47	86-88	92-94	98-00	1993	2
0060	STABLE U.S. OCEAN PLATFORMS ARE USED AS SEA STATIONS FOR AIRPORTS, RESORTS, OR SHIPPING TERMINALS	20	19	86-88	92-94	98-00	1993	2
0033	A U.S. FLOATING PLANT IS ESTABLISHED TO EXTRACT MINERALS FROM SEA WATER	15	35	86-88	92-94	98-00	1993	2
0043	WARS IN THE WEST (INCLUDING SOUTH & CENTRAL AMERICA) INVOLVE THE U.S.	29	5	86-88	92-94	98-00	1994	2
0034	BILGE AND BALLAST PETROLEUM DUMPING IS VIRTUALLY ELIMINATED	1	58	86-88	92-94	98-00	1994	2

TABLE 6-2. (Continued).

IMPLIED SCENE 3 1990-1994

EVNT	EVENT DESCRIPTION	INIT WT.A	IAL RANK	CUM.P (0.1)	ROB.D (0.5)	ATES (0.9)	TRIG DATE	SN
0045	2-, 3-, AND 4-SEATER HOVERCRAFT COMPRISE 10% OF RECREATIONAL BOATS SOLD	25	7	86-88	95-97	98-00	1995	3
0023	U.S. EXERTS MILITARY FORCE IN DEFENSE OF THE PANAMA CANAL	31	1	89-91	95-97	01-03	1996	3
0022	WORLD PRODUCTION OF MARINE FOOD INCREASES BY 70% OVER 1975 LEVELS	18	22	89-91	95-97	01-03	1996	3
0029	EXPORTS OF U.S. AGRICULTURAL PRODUCTS VIA GREAT LAKES PORTS INCREASES 50% OVER 1975 LEVELS	15	35	89-91	95-97	01-03	1996	3
0047	COAL AND NUCLEAR PROPULSION PLANTS ARE USED IN 50% OF NEW SHIP CONSTRUCTION WORLD-WIDE	7	57	89-91	95-97	01-03	1996	3
0055	TWICE AS MANY LIGHTER-ABOARD SHIPS (LASH) ARE IN USE AS WERE IN 1975	9	55	86-88	95-97	98-00	1996	3
0004	US INTERVENES MILITARILY TO ASSURE FLOW OF RAW MATERIALS (NON-PETROLEUM) FOR US INDUSTRY	30	4	89-91	95-97	01-03	1997	3
0050	DEVELOPMENT OF AT LEAST 1 COMMERCIAL SUBMARINE CARGO VESSEL IN THE 10,000 TON CLASS	23	10	89-91	96-00	01-03	1998	3
0037	SEVEN OFFSHORE NUCLEAR POWER PLANTS ARE OPERATIONAL IN U.S. WATERS	22	13	92-94	96-00	01-03	1999	3
0008	TERRORIST GROUP COMMANDEERS AND HOLDS FOR RANSOM A FUEL SHIPMENT TO A FLOATING NUCLEAR POWER PLANT	16	34	92-94	96-00	01-03	1999	3
0016	DRIFTING BARGE COLLIDES WITH A FLOATING NUCLEAR POWER PLANT	18	22	92-94	96-00	04-06	1999	3
0046	A LARGE TIDAL POWER PLANT IS IN OPERATION IN THE U.S.	11	51	92-94	96-00	04-06	1999	3
0006	NUCLEAR-POWERED SHIP SINKS ON OUTER CONTINENTAL SHELF	8	56	92-94	96-00	04-06	1999	3

IMPLIED SCENE 4 1995-1999

0056	ESTABLISHMENT OF TRANSPORTATION SYSTEM USING 1 M DWT TANKERS, SEABERTHS & OFFSHORE PETROLEUM TANKS	15	38	92-94	98-00	04-06	2000	4
0040	12 U.S. OCEAN-THERMAL ENERGY PLANTS ARE OPERATIONAL	15	36	92-94	96-00	04-06	2000	4
0057	AVERAGE SIZE OF OIL-BULK-ORE CARRIERS IN USE EXCEEDS 200,000 DWT	9	54	92-94	98-00	04-06	2000	4
0059	LARGE AIR CUSHION VEHICLE FREIGHTERS WITH EITHER CHEMICAL OR NUCLEAR POWER CARRY OCEAN-GOING CARGO	15	38	98-00	01-03	04-06	2003	4

KEY TO COLUMN HEADINGS

SIE — Surveillance Information Element code (See Table 3-2).

SCENE WT. — Relative importance of the SIE in each scene.

SCENE RANK — Rank ordering of the SIEs in each scene.

Scenes are defined as follows:

SCENE	TIME PERIOD
1	1980-1984
2	1985-1989
3	1990-1994
4	1995-1999
5	2000-2004

every event would have an impact on every Program). If in this analysis it were determined that a specific event had an impact on a specific Program, then this impact relationship would be evaluated further in the next step of the analysis (see below). Event 1 (Underwater Parks), for instance, affects the AN Program.

The Coast Guard attaches varying importance to each of its Programs, as expressed by its Program Assessment Model. The Program Assessment Model considers all Operating Programs, including several with no surveillance requirements. Therefore, the Program weights were incorporated into the Requirements Model after deleting Programs which do not have surveillance requirements, and renormalizing to 1000, as shown in Table 6-3.

Impact of Events on Program Activities. Returning to the case where a Program would be affected by the occurrence of a particular event, an assessment of the magnitude of the impact of the event on each Program Activity constituting the particular Program has been made. Continuing the above example, and referring to Appendix B, Event 1 affects the AN Program; within the AN Program it is considered to affect PA 1 (buoy surveillance) and PA 3 (beacon surveillance), both with minor impact. These PAs have therefore been given scores of 2.

It should be noted however, that no attempt has been made to weight Program Activities; PAs within a Program are assumed to be equally important to that Program.

Relationship of Surveillance Requirements to Program Activities. The final entry into the Requirements Model is a weighting factor which indicates the importance of each surveillance requirement within a Program Activity to that Program Activity. In this way, the event impact, assessed above, can be translated mathematically into an impact on each of the surveillance requirements which constitute the Program Activity. The surveillance requirement weights (2, 4, 8 direct assessments and normalized values) are given in Appendix E.

Requirements Model. The foregoing discussion reviews all of the inputs required to develop a list of surveillance requirements which are valued in the context of Coast Guard Objectives and Programs, and the future pressures on the Coast Guard due to external factors

TABLE 6-3. COAST GUARD OPERATING PROGRAM WEIGHTS

Ranking	Program	USCG Weights[a]	Weights Used by FI
1	Military Operations/Preparedness (MO/MP)	17.666	191
2	Search and Rescue (SAR)	11.413	123
3	Commercial Vessel Safety (CVS)	10.798	117
4	Enforcement of Laws and Treaties (ELT)	10.453	113
5	Ice Operations (IO)	10.159	110
6	Port Safety and Security (PSS)	8.756	107[c]
7	Short Range Aids to Navigation (AN)	8.108	88
8	Marine Environmental Protection (MEP)	5.413	59
9	Recreational Boating Safety (RBS)	4.354	47
10	Reserve Forces (RT)	3.998	b
11	Radionavigation Aids (RA)	3.572	b
12	Marine Science Activities (MSA)	2.700	29
13	Bridge Administration (BA)	1.441	16
14	Deepwater Ports (DWP)	1.167	c
		100.000	1000

[a]Reference 42, Enclosure (1).

[b]Reserve Forces and Radionavigation Aids did not have surveillance functions so did not receive a weight.

[c]Deepwater Ports (DWP) is included with Port Safety and Security (PSS).

RELATIVE IMPORTANCE OF ANY SURVEILLANCE REQUIREMENT

$$W'_j = \sum_{i=1}^{60} \sum_{k=1}^{92} \sum_{h=1}^{11} A_i \cdot P_{ih} \cdot Q_h \cdot E_{ik} \cdot S_{jk}$$

For $j = 1, 2, \ldots, 71$.

Where

A_i is the normalized weight (relative importance) of the impact of Event i on Coast Guard Objectives.

B'_i is the weight (relative importance) of the impact of Event i on both Coast Guard Objectives and surveillance requirements.

B_i is the weight of Event i normalized to 1000:

$$B_i = 1000\ B'_i / \sum_{i=1}^{60} B'_i$$

E_{ik} is the impact value of Event i on Program Activity k where k is a Program Activity under a Program which would be affected by the occurrence of Event i.

P_{ih} is the impact of Event i on Program h, $P_{ih} = 1$ if program would be affected, 0 if not.

Q_h is the normalized weight (relative importance) of Program h.

RELATIVE IMPORTANCE OF ANY EVENT

$$B'_j = \sum_{j=1}^{71} \sum_{k=1}^{92} \sum_{h=1}^{11} A_i \cdot P_{ih} \cdot Q_h \cdot E_{ik} \cdot S_{jk}$$

For $i = 1, 2, \ldots, 60$.

S_{jk} is the normalized weight (relative importance) of SIE j with respect to Program Activity k.

W'_j is the resulting weight (relative importance) of SIE j.

W_j is the weight of SIE j normalized to 1000:

$$W_j = 1000\ W'_j / \sum_{j=1}^{71} W'_j.$$

h is the index of the set of Operating Programs H with surveillance requirements, $H = \{1,2,\ldots,11\}$.

i is the index of the set of future Events I, $I = \{1,2,\ldots,60\}$.

j is the index of the set of Surveillance Information Elements (SIEs) J, $J = \{1,2,\ldots,71\}$.

k is the index of the set of Program Activities K, $K = \{1,2,\ldots,92\}$.

FIGURE 6-2. SURVEILLANCE REQUIREMENTS MODEL

(events). The input data for the model are contained in Appendix F. In order to obtain a quantitative measure of the relative importance of each surveillance requirement, a mathematical model has been employed which incorporates the various weighting factors and scores discussed above. This mathematical model is given in Figure 6-2.

CHAPTER 7 - SURVEILLANCE REQUIREMENTS: MODEL RESULTS, SENSITIVITY ANALYSIS AND CONCLUSIONS

Chapter 6 has described the Requirements Model in detail, including the input data necessary for its operation. The purpose of Chapter 7 is to outline the procedure used in exercising the model and to present the results obtained. Conclusions drawn from the analysis of surveillance requirements are also presented. Recall, from Chapter 6, that the objectives or outputs of the model are:

- Time-phased, weighted, and ranked surveillance requirements aggregated by Program and overall.
- A final weighting of the events which reflects both their impact on the Coast Guard and their impact on Coast Guard surveillance requirements.
- The means to test the sensitivity of surveillance requirements to event probabilities of occurrence.

To obtain time-phased surveillance requirements weighted by importance (the Second Iteration indicated in the complete Flow Chart, Figure 7-1), the model has been exercised five times (once for each scene). Events have been introduced according to the scenes implied by their trigger dates (refer to Table 6-2). After events have been introduced their effects on Coast Guard surveillance can be expected to continue; to illustrate from recent history, surveillance requirements generated by establishment of the Fisheries Conservation Zone (an event) will continue indefinitely. The Requirements Model accommodates this phenomenon by aggregating requirements scores from scene to scene; the numerical (non-normalized) impact of each event is carried forward after it is initially introduced. Consequently, the requirements weights for Scene 5 represent the combined effects of all 60 events.

Tables 7-1 and 7-2 present the model results in order of SIE code (for ease of cross-reference) and Scene 5 rank, respectively. In these tables weights (normalized to 1000) and ranks for each

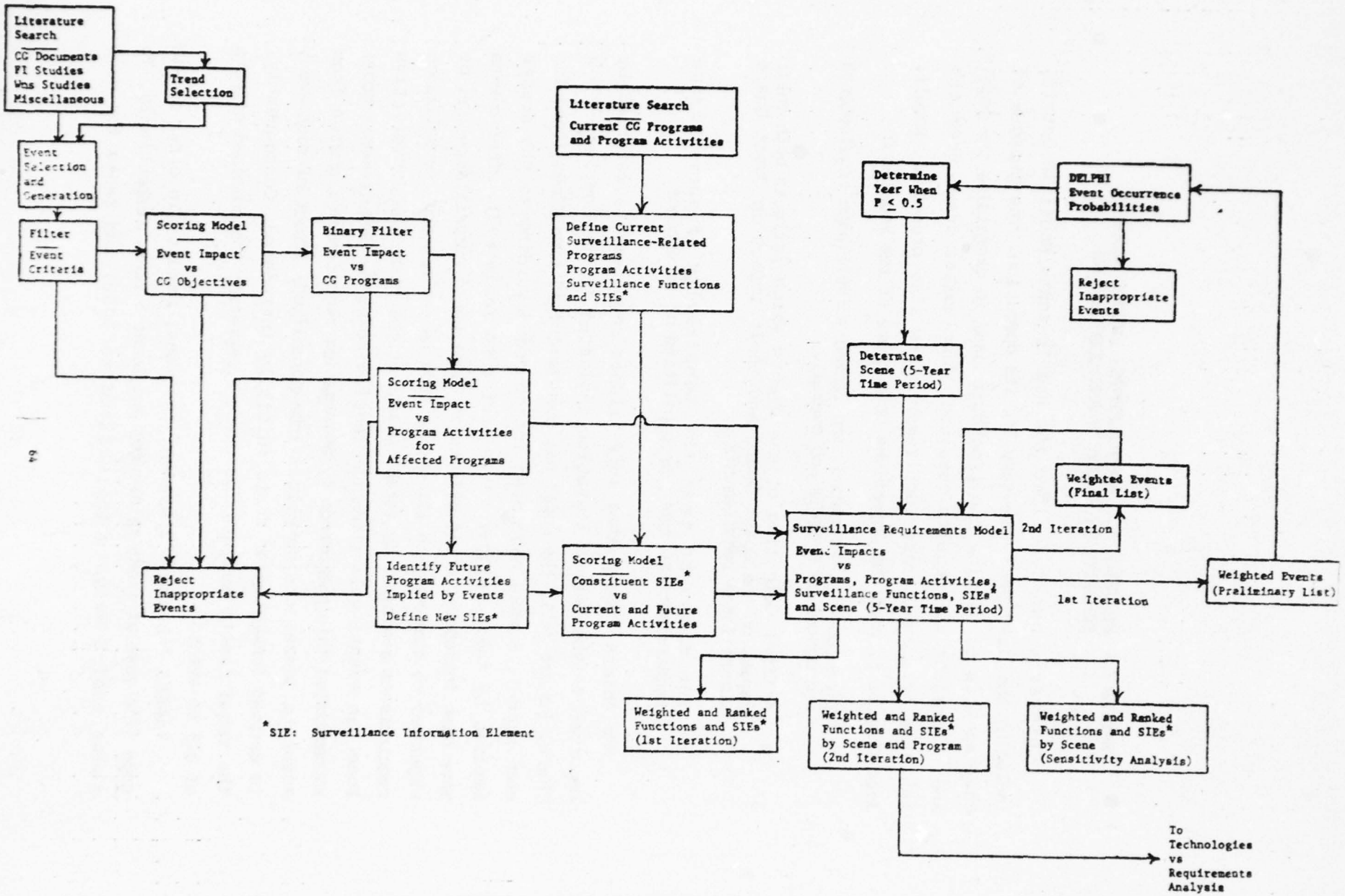


FIGURE 7-1. SURVEILLANCE REQUIREMENTS FLOW CHART

TABLE 7-1. FUTURE SURVEILLANCE REQUIREMENTS LISTED IN ORDER OF SIE CODE

SIE	SURVEILLANCE FUNCTION AND SIE DESCRIPTION	SCEN 1 WT.	SCEN 1 RNK	SCEN 2 WT.	SCEN 2 RNK	SCEN 3 WT.	SCEN 3 RNK	SCEN 4 WT.	SCEN 4 RNK	SCEN 5 WT.	SCEN 5 RNK
001	DETECT: AIRBORNE AIRCRAFT, MISSILE, AIRSHIP	7	34	10	27	10	29	10	28	10	28
002	DETECT: LARGE VESSEL (150'+)	38	10	43	7	47	7	47	7	47	7
003	DETECT: MEDIUM SIZED VESSEL (40'-150')	47	6	48	6	53	6	53	6	53	6
004	DETECT: SMALL VESSEL(16'-40'), METAL BUOY, BEACON, ICEBERG, AFLOAT SEAPLANE	47	5	68	4	76	2	75	2	75	2
005	DETECT:SWIMMER, NON-METAL BUOY, FISH TRAP MARKER, GROWLER, DITCHED AIRCRAFT	29	13	28	14	30	13	30	12	30	12
006	DETECT: ICE FIELD, ICE JAM	6	36	5	37	4	43	4	43	4	43
007	DETECT: SOLID POLLUTANT, TARBALL	20	16	13	22	11	27	12	27	12	27
008	DETECT: DIVER (UNDERWATER SWIMMER)	15	20	13	23	13	21	13	22	13	22
009	DETECT: SMALL SUBMERGED SUBMERSIBLE, MINE, SUNKEN VESSEL	16	19	9	31	9	30	9	30	9	30
010	DETECT: LARGE SUBMERGED SUBMARINE			6	35	4	45	4	45	4	45
011	DETECT: SEA BOTTOM			0	59	0	62	0	62	0	62
012	DETECT: SEA SURFACE			1	58	0	61	0	61	0	61
013	DETECT: LIQUID POLLUTANT	46	7	29	12	22	15	23	15	23	15
014	DETECT: GASEOUS POLLUTANT	13	28	8	32	7	34	7	33	7	33
015	DETECT: ELECTROMAGNETIC EMISSION: RADIO (10 KHZ-30 GHZ)	3	46	10	28	13	22	13	23	13	23
016	DETECT: ELECTROMAGNETIC EMISSION: RADAR (200-30,000 MHZ)										
017	DETECT: ELECTROMAGNETIC EMISSION: HEAT (1-400 THZ)	4	44	2	53	1	54	1	54	1	54
018	DETECT: ELECTROMAGNETIC EMISSION: LIGHT (400-750 THZ)	14	22	16	17	18	18	18	18	18	18
019	DETECT: SOUND EMISSION IN AIR	14	24	16	18	20	16	20	16	20	16
020	DETECT: SOUND EMISSION IN WATER	3	47	5	42	7	33	6	34	6	34
021	DETECT: NUCLEAR RADIATION: ALPHA AND BETA PARTICLES, GAMMA RAYS	23	14	15	19	13	23	14	21	14	21
022	LOCATE: RANGE OR BEARING	13	27	14	21	15	19	15	19	15	19
023	LOCATE: RANGE AND BEARING	66	3	83	1	80	1	79	1	79	1
024	LOCATE: ALTITUDE OR DEPTH	42	8	39	9	32	10	32	10	32	10
025	LOCATE: GEOGRAPHICAL POSITION	88	1	73	2	67	3	67	3	67	3
026	IDENTIFY: NAME OR IDENTIFYING NUMBER	32	12	29	11	32	11	31	11	31	11
027	IDENTIFY: FLAG (U.S. OR FOREIGN)	13	26	12	24	13	25	13	24	13	24
028	IDENTIFY: FRIEND OR FOE			10	29	11	28	10	29	10	29
029	IDENTIFY: TYPE	40	9	43	8	44	8	44	8	44	8
030	IDENTIFY: COLOR	20	15	19	16	19	17	19	17	19	17
031	IDENTIFY: SHAPE	4	41	5	40	6	35	6	35	6	35
032	IDENTIFY: FREQUENCY	1	54	3	51	3	48	3	47	3	47
033	IDENTIFY: CHARACTERISTIC CODE	20	17	21	15	23	14	23	14	23	14
034	OBSERVE: STRUCTURAL INTEGRITY	83	2	70	3	56	4	58	4	58	4
035	OBSERVE: AUDIBLE/VISIBLE/RADAR RANGE	9	30	12	26	13	26	13	26	13	26
036	OBSERVE: VISIBILITY ARCS	5	39	5	41	5	36	5	36	5	36
037	OBSERVE: MOVEMENT OF OBJECT OF INTEREST	54	4	55	5	55	5	55	5	55	5
038	OBSERVE: TRANSMISSION TIME SCHEDULE	14	23	14	20	14	20	14	20	14	20

KEY TO COLUMN HEADINGS

SIE — Surveillance Information Element code (See Table 3-2).

SCENE WT. — Relative importance of the SIE in each scene.

SCENE RANK — Rank ordering of the SIEs in each scene.

Scenes are defined as follows:

SCENE	TIME PERIOD
1	1980-1984
2	1985-1989
3	1990-1994
4	1995-1999
5	2000-2004

TABLE 7-1. (Continued).

SIE	SURVEILLANCE FUNCTION AND SIE DESCRIPTION	SCEN 1 WT.	SCEN 1 RNK	SCEN 2 WT.	SCEN 2 RNK	SCEN 3 WT.	SCEN 3 RNK	SCEN 4 WT.	SCEN 4 RNK	SCEN 5 WT.	SCEN 5 RNK
039	OBSERVE: NUMBER OF OBJECTS PER TIME INTERVAL	4	43	3	49	2	52	2	52	2	52
040	OBSERVE: FISHING ACTIVITY	0	55	1	57	1	56	1	56	1	56
041	OBSERVE: FISHERY SUPPORT OPERATIONS	0	56	0	69	0	63	0	63	0	63
042	OBSERVE: SUSPICIOUS ACTIVITY: HOVERING	14	22	12	25	13	24	13	25	13	25
043	OBSERVE: SUSPICIOUS ACTIVITY: TRANSFERRING CARGO	5	40	3	47	3	47	3	48	3	48
044	OBSERVE: SUSPICIOUS ACTIVITY: FLEEING	2	53	1	56	1	57	1	57	1	57
045	OBSERVE: SUSPICIOUS ACTIVITY: DISCHARGING POLLUTANT	6	35	4	43	3	46	4	46	4	46
046	OBSERVE: HOSTILE ACTIVITY	27	18	28	13	31	12	30	13	30	13
047	OBSERVE: HAZARDOUS ACTIVITY	34	11	37	10	40	9	42	9	42	9
048	OBSERVE: FISH CATCH: SPECIES	-2	57	0	60	0	58	0	58	0	58
049	OBSERVE: FISH CATCH: FISH SIZE	-2	57	0	60	0	58	0	58	0	58
050	OBSERVE: FISH CATCH: QUANTITY	-2	57	0	60	0	58	0	58	0	58
051	OBSERVE: CONTRABAND: CHEMICAL, BIOLOGICAL, RADIOLOGICAL DEVICES	3	48	2	52	3	50	3	50	3	50
052	OBSERVE: CONTRABAND: DRUGS	4	42	1	54	1	53	1	53	1	53
053	OBSERVE: CONTRABAND: WEAPONS AND MUNITIONS	13	29	7	33	8	32	8	32	8	32
054	OBSERVE: ILLEGAL ALIENS	6	38	3	50	3	51	3	51	3	51
055	OBSERVE: ICE THICKNESS	6	36	5	37	4	43	4	43	4	43
056	OBSERVE: SIZE OF OBJECT	8	33	5	39	5	37	5	38	5	38
057	OBSERVE: AREA COVERED BY OBJECT(S) OF INTEREST	13	25	10	30	8	31	8	31	8	31
058	OBSERVE: SEAS AND SWELLS: HEIGHT			0	65	0	66	0	66	0	66
059	OBSERVE: SEAS AND SWELLS: PERIOD			0	65	0	66	0	66	0	66
060	OBSERVE: PROFILES: DEPTH VS TEMPERATURE	9	31	6	34	5	38	5	37	5	37
061	OBSERVE: PROFILES: DEPTH VS SALINITY	9	31	6	36	5	39	5	39	5	39
062	OBSERVE: SURFACE WEATHER: TEMPERATURE			0	65	0	66	0	66	0	66
063	OBSERVE: SURFACE WEATHER: PRESSURE			0	63	0	64	0	64	0	64
064	OBSERVE: SURFACE WEATHER: HUMIDITY			0	65	0	66	0	66	0	66
065	OBSERVE: CLOUD TYPE			0	70	0	70	0	70	0	70
066	OBSERVE: WIND VELOCITY			0	63	0	64	0	64	0	64
067	OBSERVE: NATURE OF DISTRESS: DISABLED OR INJURED	3	45	3	48	3	49	3	49	3	49
068	OBSERVE: NATURE OF DISTRESS: AFIRE	2	50	3	44	4	40	4	40	4	40
069	OBSERVE: NATURE OF DISTRESS: SINKING	2	50	3	44	4	40	4	40	4	40
070	OBSERVE: NATURE OF DISTRESS: AGROUND	2	50	3	44	4	40	4	40	4	40
071	OBSERVE: NATURE OF DISTRESS: SUNK	2	49	1	55	1	55	1	55	1	55

KEY TO COLUMN HEADINGS

SIE — Surveillance Information Element code (See Table 3-2).

SCENE WT. — Relative importance of the SIE in each scene.

SCENE RANK — Rank ordering of the SIEs in each scene.

Scenes are defined as follows:

SCENE	TIME PERIOD
1	1980-1984
2	1985-1989
3	1990-1994
4	1995-1999
5	2000-2004

TABLE 7-2. FUTURE SURVEILLANCE REQUIREMENTS LISTED IN ORDER OF SCENE 5 RANK

SIE	SURVEILLANCE FUNCTION AND SIE DESCRIPTION	SCEN WT.	E 1 RNK	SCEN WT.	E 2 RNK	SCEN WT.	E 3 RNK	SCEN WT.	E 4 RNK	SCEN WT.	E 5 RNK
023	LOCATE: RANGE AND BEARING	66	3	83	1	80	1	79	1	79	1
004	DETECT: SMALL VESSEL(16'-40'), METAL BUOY, BEACON, ICEBERG, AFLOAT SEAPLANE	47	5	68	4	76	2	75	2	75	2
025	LOCATE: GEOGRAPHICAL POSITION	88	1	73	2	67	3	67	3	67	3
034	OBSERVE: STRUCTURAL INTEGRITY	83	2	70	3	56	4	58	4	58	4
037	OBSERVE: MOVEMENT OF OBJECT OF INTEREST	54	4	55	5	55	5	55	5	55	5
003	DETECT: MEDIUM SIZED VESSEL (40'-150')	47	6	48	6	53	6	53	6	53	6
002	DETECT: LARGE VESSEL (150'+)	38	10	43	7	47	7	47	7	47	7
029	IDENTIFY: TYPE	40	9	43	8	44	8	44	8	44	8
047	OBSERVE: HAZARDOUS ACTIVITY	34	11	37	10	40	9	41	9	41	9
024	LOCATE: ALTITUDE OR DEPTH	41	8	39	9	32	10	32	10	32	10
026	IDENTIFY: NAME OR IDENTIFYING NUMBER	32	12	29	11	31	11	32	11	32	11
005	DETECT:SWIMMER, NON-METAL BUOY, FISH TRAP MARKER, GROWLER, DITCHED AIRCRAFT	29	13	28	14	30	13	30	12	30	12
046	OBSERVE: HOSTILE ACTIVITY	17	18	26	13	32	12	30	13	30	13
033	IDENTIFY: CHARACTERISTIC CODE	20	17	21	15	23	14	23	14	23	14
013	DETECT: LIQUID POLLUTANT	46	7	29	12	22	15	23	15	23	15
019	DETECT: SOUND EMISSION IN AIR	14	24	16	18	20	16	20	16	20	16
030	IDENTIFY: COLOR	20	15	19	16	19	17	19	17	19	17
018	DETECT: ELECTROMAGNETIC EMISSION: LIGHT (400-750 THZ)	14	22	16	17	18	18	18	18	18	18
022	LOCATE: RANGE OR BEARING	13	27	14	21	15	19	15	19	15	19
038	OBSERVE: TRANSMISSION TIME SCHEDULE	14	23	14	20	14	20	14	20	14	20
021	DETECT: NUCLEAR RADIATION: ALPHA AND BETA PARTICLES, GAMMA RAYS	23	14	15	19	13	23	14	21	14	21
008	DETECT: DIVER (UNDERWATER SWIMMER)	15	20	13	23	13	21	13	22	13	22
015	DETECT: ELECTROMAGNETIC EMISSION: RADIO (10 KHZ-30 GHZ)	3	46	10	26	13	22	13	23	13	23
027	IDENTIFY: FLAG (U.S. OR FOREIGN)	13	26	12	24	13	25	13	24	13	24
042	OBSERVE: SUSPICIOUS ACTIVITY: HOVERING	14	21	12	25	13	24	13	25	13	25
035	OBSERVE: AUDIBLE/VISIBLE/RADAR RANGE	9	30	12	26	13	26	13	26	13	26
007	DETECT: SOLID POLLUTANT, TARBALL	20	16	13	22	11	27	12	27	12	27
001	DETECT: AIRBORNE AIRCRAFT, MISSILE, AIRSHIP	7	34	10	27	10	29	10	26	10	28
028	IDENTIFY: FRIEND OR FOE	1	1	10	29	11	28	10	29	10	29
009	DETECT: SMALL SUBMERGED SUBMERSIBLE, MINE, SUNKEN VESSEL	16	19	9	31	9	30	9	30	9	30
057	OBSERVE: AREA COVERED BY OBJECT(S) OF INTEREST	13	25	10	30	8	31	8	31	8	31
053	OBSERVE: CONTRABAND: WEAPONS AND MUNITIONS	13	29	7	33	8	32	8	32	8	32
014	DETECT: GASEOUS POLLUTANT	13	28	8	32	7	34	7	33	7	33
020	DETECT: SOUND EMISSION IN WATER	3	47	5	42	7	33	6	34	6	34
031	IDENTIFY: SHAPE	4	41	5	40	6	35	6	35	6	35

KEY TO COLUMN HEADINGS

SIE — Surveillance Information Element code (See Table 3-2).

SCENE WT. — Relative importance of the SIE in each scene.

SCENE RANK — Rank ordering of the SIEs in each scene.

Scenes are defined as follows:

SCENE	TIME PERIOD
1	1980-1984
2	1985-1989
3	1990-1994
4	1995-1999
5	2000-2004

TABLE 7-2. (Continued).

SIE	SURVEILLANCE FUNCTION AND SIE DESCRIPTION	SCEN 1 WT.	SCEN 1 RNK	SCEN 2 WT.	SCEN 2 RNK	SCEN 3 WT.	SCEN 3 RNK	SCEN 4 WT.	SCEN 4 RNK	SCEN 5 WT.	SCEN 5 RNK
036	OBSERVE: VISIBILITY ARCS	5	39	5	42	5	36	5	36	5	36
060	OBSERVE: PROFILES: DEPTH VS TEMPERATURE	9	31	6	34	5	38	5	37	5	37
056	OBSERVE: SIZE OF OBJECT	8	33	5	39	5	37	5	38	5	38
061	OBSERVE: PROFILES: DEPTH VS SALINITY	9	31	6	36	5	39	5	39	5	39
068	OBSERVE: NATURE OF DISTRESS: AFIRE	2	50	3	44	4	40	4	40	4	40
069	OBSERVE: NATURE OF DISTRESS: SINKING	2	50	3	44	4	40	4	40	4	40
070	OBSERVE: NATURE OF DISTRESS: AGHOUND	2	50	3	44	4	40	4	40	4	40
006	DETECT: ICE FIELD, ICE JAM	6	36	5	37	4	43	4	43	4	43
055	OBSERVE: ICE THICKNESS	6	36	5	37	4	43	4	43	4	43
010	DETECT: LARGE SUBMERGED SUBMARINE	1	1	6	35	4	45	4	45	4	45
045	OBSERVE: SUSPICIOUS ACTIVITY: DISCHARGING POLLUTANT	6	35	4	43	3	46	4	46	4	46
032	IDENTIFY: FREQUENCY	1	54	3	51	3	48	3	47	3	47
043	OBSERVE: SUSPICIOUS ACTIVITY: TRANSFERRING CARGO	5	40	3	47	3	47	3	48	3	48
067	OBSERVE: NATURE OF DISTRESS: DISABLED OR INJURED	3	45	3	48	3	49	3	49	3	49
051	OBSERVE: CONTRABAND: CHEMICAL, BIOLOGICAL, RADIOLOGICAL DEVICES	3	48	2	52	3	50	3	50	3	50
054	OBSERVE: ILLEGAL ALIENS	6	38	3	50	3	51	3	51	3	51
039	OBSERVE: NUMBER OF OBJECTS PER TIME INTERVAL	4	43	3	49	2	52	2	52	2	52
052	OBSERVE: CONTRABAND: DRUGS	4	42	1	54	1	53	1	53	1	53
017	DETECT: ELECTROMAGNETIC EMISSION: HEAT (1-400 THZ)	4	44	2	53	1	54	1	54	1	54
071	OBSERVE: NATURE OF DISTRESS: SUNK	2	49	1	55	1	55	1	55	1	55
040	OBSERVE: FISHING ACTIVITY	0	55	1	57	1	56	1	56	1	56
044	OBSERVE: SUSPICIOUS ACTIVITY: FLEEING	2	53	1	56	1	57	1	57	1	57
048	OBSERVE: FISH CATCH: SPECIES	-1	57	0	60	0	58	0	58	0	58
049	OBSERVE: FISH CATCH: FISH SIZE	-1	57	0	60	0	58	0	58	0	58
050	OBSERVE: FISH CATCH: QUANTITY	-1	57	0	60	0	58	0	58	0	58
012	DETECT: SEA SURFACE	1	1	1	58	0	61	0	61	0	61
011	DETECT: SEA BOTTOM	1	1	0	59	0	62	0	62	0	62
041	OBSERVE: FISHERY SUPPORT OPERATIONS	0	56	0	69	0	63	0	63	0	63
063	OBSERVE: SURFACE WEATHER: PRESSURE	1	1	0	63	0	64	0	64	0	64
066	OBSERVE: WIND VELOCITY	1	1	0	63	0	64	0	64	0	64
058	OBSERVE: SEAS AND SWELLS: HEIGHT	1	1	0	65	0	66	0	66	0	66
059	OBSERVE: SEAS AND SWELLS: PERIOD	1	1	0	65	0	66	0	66	0	66
062	OBSERVE: SURFACE WEATHER: TEMPERATURE	1	1	0	65	0	66	0	66	0	66
064	OBSERVE: SURFACE WEATHER: HUMIDITY	1	1	0	65	0	66	0	66	0	66
065	OBSERVE: CLOUD TYPE	1	1	0	70	0	70	0	70	0	70

KEY TO COLUMN HEADINGS

SIE — Surveillance Information Element code (See Table 3-2).

SCENE WT. — Relative importance of the SIE in each scene.

SCENE RANK — Rank ordering of the SIEs in each scene.

Scenes are defined as follows:

SCENE	TIME PERIOD
1	1980-1984
2	1985-1989
3	1990-1994
4	1995-1999
5	2000-2004

requirement are given for each scene. Information in these tables is an overall aggregation across all Programs; similar tables for each Operating Program have been developed and are given in Appendix G.

Because SIE descriptions shown in these tables are necessarily generic, their meaning can be greatly enhanced by referring to the specific elements of each requirement subsumed in the tabular listing. For instance, the specific elements constituting "Locate: range and bearing" (Rank 1 in Scene 5), and the Programs and Program Activities affected are:

PROG	PA	PROGRAM ACTIVITY	FUNCTION	SIE	SURVEILLANCE INFORMATION ELEMENT
ELT	22	ANTI-SMUGGLING SURVEILLANCE	LOCATE	023	RANGE AND BEARING TO SMUGGLING VESSEL
MOMP	50	AAW SURVEILLANCE	LOCATE	023	RANGE AND BEARING OF AIRCRAFT/MISSILE
MOMP	51	ASUW SURVEILLANCE	LOCATE	023	RANGE AND BEARING OF VESSEL
MOMP	52	ASW SURVEILLANCE	LOCATE	023	RANGE AND BEARING OF SUBMARINE
MOMP	53	NGFS SURVEILLANCE	LOCATE	023	RANGE AND BEARING OF TARGET/AIMING POINT
PSS	77	PORT AND WATERWAY SURVEILLANCE	LOCATE	023	RANGE AND BEARING OF THREATENING VESSELS
PSS	78	CONTROL SELECTED VESSEL MVMTS	LOCATE	023	RANGE AND BEARING OF THREATENING/THREATENED VESSELS
PSS	79	VESSEL TRAFFIC SERVICES	LOCATE	023	RANGE AND BEARING TO VESSELS IN VTS SYSTEM
RBS	87	REGATTA SURVEILLANCE	LOCATE	023	RANGE AND BEARING OF INTRUDER
SAR	90	ALERTING AND LOCATING SYSTEMS	LOCATE	023	RANGE AND BEARING OF EMITTER
SAR	91	SURFACE SEARCH	LOCATE	023	RANGE AND BEARING OF SEARCH OBJECT
CVS	14	UNDERSEA STRUCTURE INSPECTION	LOCATE	023	HORIZONTAL POSITION OF DEFECT IN THE STRUCTURE
CVS	13	OFFSHORE PLATFORM INSPECTION	LOCATE	023	HORIZONTAL POSITION OF DEFECT IN THE STRUCTURE
PSS	80	OFFSHORE ASSET PROTECTION	LOCATE	023	RANGE AND BEARING OF THREAT
SAR	92	UNDERWATER SEARCH	LOCATE	023	RANGE AND BEARING OF SUBMERSIBLE

Similarly, "Detect: Small vessel (16'-40'), metal buoy, visible object (beacon), large iceberg, afloat seaplane" (Rank 2 in Scene 5) is composed of the following elements:

PROG	PA	PROGRAM ACTIVITY	FUNCTION	SIE	SURVEILLANCE INFORMATION ELEMENT
AN	1	BUOY SURVEILLANCE	DETECT	004	METAL BUOY
AN	2	BEACON SURVEILLANCE	DETECT	004	BEACON, VISUAL OR RADAR
ELT	21	GEAR CONFLICT SURVEILLANCE	DETECT	004	SMALL VESSEL
ELT	22	ANTI-SMUGGLING SURVEILLANCE	DETECT	004	SMALL VESSEL
MOMP	51	ASUW SURVEILLANCE	DETECT	004	SMALL VESSEL
MOMP	53	NGFS SURVEILLANCE	DETECT	004	LAND TARGET OR AIMING POINT
NSA	60	ICEBERG SURVEILLANCE	DETECT	004	LARGE ICEBERG
NSA	67	NATIONAL DATA BUOY PROGRAM	DETECT	004	DATA BUOY
PSS	77	PORT AND WATERWAY SURVEILLANCE	DETECT	004	SMALL THREATENING VESSELS
PSS	78	CONTROL SELECTED VESSEL MVMTS	DETECT	004	SMALL THREATENING/THREATENED VESSELS
RBS	87	REGATTA SURVEILLANCE	DETECT	004	SMALL PARTICIPATING/INTRUDING/ENDANGERED VESSELS
SAR	91	SURFACE SEARCH	DETECT	004	SMALL VESSEL, AFLOAT SEAPLANE
PSS	80	OFFSHORE ASSET PROTECTION	DETECT	004	SMALL VESSEL

and, "Locate: Geographical position," (Rank 3 in Scene 5) consists of:

PROG	PA	PROGRAM ACTIVITY	FUNCTION	SIE	SURVEILLANCE INFORMATION ELEMENT
AN	1	BUOY SURVEILLANCE	LOCATE	025	GEOGRAPHICAL POSITION OF BUOY
ELT	20	FISHING VESSEL SURVEILLANCE	LOCATE	025	GEOGRAPHICAL POSITION OF FISHING VESSEL
ELT	21	GEAR CONFLICT SURVEILLANCE	LOCATE	025	GEOGRAPHICAL POSITION OF VESSELS AND MARKERS
ELT	22	ANTI-SMUGGLING SURVEILLANCE	LOCATE	025	GEOGRAPHICAL POSITION OF SMUGGLING VESSEL
IO	30	ICE SURVEILLANCE	LOCATE	025	GEOGRAPHICAL POSITION OF ICE FIELDS
IO	31	FLOOD (ICE JAM) SURVEILLANCE	LOCATE	025	GEOGRAPHICAL POSITION OF ICE JAMS
MEP	40	COASTAL POLLUTION SURVEILLANCE	LOCATE	025	GEOGRAPHICAL POSITION OF POLLUTANT
MEP	41	HARBOR POLLUTION SURVEILLANCE	LOCATE	025	GEOGRAPHICAL POSITION OF POLLUTANT
NOMP	53	NGFS SURVEILLANCE	LOCATE	025	GEOGRAPHICAL POSITION OF TARGET/AIMING POINT
NOMP	54	DISASTER CONTROL SURVEILLANCE	LOCATE	025	GEOGRAPHICAL POSITION
NSA	62	ICEBERG SURVEILLANCE	LOCATE	025	GEOGRAPHIC POSITION
NSA	61	SEA TEMPERATURE SURVEYS	LOCATE	025	GEOGRAPHICAL POSITION OF OBSERVATION
NSA	62	OCEAN SOUNDINGS PROGRAM	LOCATE	025	GEOGRAPHICAL POSITION OF OBSERVATION
NSA	63	STANDARD OCEANO. SECTIONS	LOCATE	025	GEOGRAPHICAL POSITION OF SECTION
NSA	64	PATHYTHERMOGRAPH OBSERVATIONS	LOCATE	025	GEOGRAPHICAL POSITION OF OBSERVATION
NSA	65	TARPAN. OBSERVATIONS	LOCATE	025	GEOGRAPHIC POSITION OF OBSERVATION
NSA	66	SURFACE CURRENT OBSERVATIONS	LOCATE	025	GEOGRAPHICAL POSITION OF OBSERVATION
NSA	67	NATIONAL DATA BUOY PROGRAM	LOCATE	025	GEOGRAPHICAL POSITION OF BUOY
NSA	68	SURFACE WEATHER OBSERVATIONS	LOCATE	025	GEOGRAPHICAL POSITION OF OBSERVATION
PSS	76	SPECIAL VESSEL SURVEILLANCE	LOCATE	025	GEOGRAPHICAL POSITION OF SPECIAL INTEREST VESSEL
PSS	76	CONTROL SELECTED VESSEL MVMTS	LOCATE	025	GEOGRAPHICAL POSITION OF SELECTED VESSEL
PSS	79	VESSEL TRAFFIC SERVICES	LOCATE	025	GEOGRAPHICAL POSITION OF VESSELS IN VTS SYSTEM
SAR	90	ALERTING AND LOCATING SYSTEMS	LOCATE	025	GEOGRAPHICAL POSITION OF EMITTER
SAR	91	SURFACE SEARCH	LOCATE	025	GEOGRAPHICAL POSITION OF SEARCH OBJECT
ELT	23	UNDERSEA MINING SURVEILLANCE	LOCATE	025	GEOGRAPHICAL POSITION OF MINING VESSEL OR FLOATING PLANT
CVS	15	UNDERSEA PIPELINE INSPECTION	LOCATE	025	GEOGRAPHICAL POSITION OF DEFECT
SAR	92	UNDERWATER SEARCH	LOCATE	025	GEOGRAPHICAL POSITION OF SUBMERSIBLE
MEP	42	INT'L POLLUTION SURVEILLANCE	LOCATE	025	GEOGRAPHICAL POSITION OF POLLUTANT

As a final example, "Observe: Structural Integrity," (Rank 4 in Scene 5) includes:

PROG	PA	PROGRAM ACTIVITY	FUNCTION	SIE	SURVEILLANCE INFORMATION ELEMENT
PSS	75	FACILITY INSPECTION	OBSERVE	034	STRUCTURAL INTEGRITY OF FACILITY
CVS	14	UNDERSEA STRUCTURE INSPECTION	OBSERVE	034	STRUCTURAL INTEGRITY
CVS	15	UNDERSEA PIPELINE INSPECTION	OBSERVE	034	STRUCTURAL INTEGRITY OF PIPELINE
CVS	13	OFFSHORE PLATFORM INSPECTION	OBSERVE	034	STRUCTURAL INTEGRITY

This listing is continued for all requirements in Appendix H.

A review of the ranking of requirements in Table 7-2 appears to generally support intuitive a priori judgments; one would expect detection of medium-sized vessels (SIE Code 003) to rank high in importance, for instance. Why some others, such as "structural integrity" (SIE code 034), rank high may not be immediately obvious. Upon reflection, however, this result is not unreasonable; structural integrity implies a concern for safety (highest weighted Coast Guard

Objective) and it is related to the CVS and PSS Programs (both of which are heavily weighted). These reasonable and intuitively satisfying results tend to validate the Requirements Model.

The second objective of the Requirements Model was a final weighting and ranking of the events, reflecting their importance to both the Coast Guard as a whole (Wt. A) and its surveillance requirements (Wt. B). This information is given in Table 7-3 (which is an extension and re-arrangement of Tables 5-4 and 6-2). Not surprisingly, event ranks shift substantially when the focus changes from the Coast Guard as a whole (initial rank) to surveillance requirements (final rank).

The third objective of the Requirements Model, a sensitivity analysis, has been performed and described in detail in Appendix I. Generally, the requirements ranks given in Table 7-2 are relatively insensitive to changes in the probability of event occurrences over the range 0.3 to 0.7, although there are some exceptions. These are listed in Table I-3.

As a result of exercising the Requirements Model the weights and ranks of surveillance requirements have been developed by scene for each Program and across all Programs. The phased weights and ranks across all Programs serve as inputs to the technologies versus requirements analysis discussed later in the study. It should be borne in mind that the surveillance requirements thus defined reflect only the impact of future events (and strictly only the 60 events used in this study). They do not reflect the weights and ranks of current (1979) surveillance requirements; rather, they represent changes in emphasis imposed by future developments.

The relative importance of the requirements varies widely, as is clearly shown in Figure 7-2. (Although a negative slope is to be expected, no particular importance attaches to the observed close approximation to an exponential curve). The relationship of requirement importance (weight) to rank is made even more graphic in Figure 7-3. For instance, 50% of the total weight is concentrated in the requirements ranked 1-9; 75% in ranks 1-19. The 30 lowest ranked requirements account for only 5% of the total weight. Because relative importance diminishes so rapidly, little will be lost by

TABLE 7-3. SUMMARY OF THE SIGNIFICANCE OF FUTURE EVENTS TO COAST GUARD SURVEILLANCE REQUIREMENTS

EVNT	EVENT DESCRIPTION	INIT WT.A	IAL RANK	CUM.P (0.1)	ROB.D (0.5)	ATES (0.9)	TRIG DATE	SN	FINA WT.B	L RANK
0041	WARS IN THE WEST (INCLUDING SOUTH & CENTRAL AMERICA) INVOLVE THE U.S.	29	5	86-88	92-94	96-00	1994	2	118	1
0034	US INTERVENES MILITARILY TO ASSURE FLOW OF RAW MATERIALS (NON-PETROLEUM) FOR US INDUSTRY	30	4	89-91	95-97	01-03	1997	3	98	2
0025	U.S. INTERVENES MILITARILY TO ASSURE CONTINUOUS FLOW OF PETROLEUM FOR U.S. INDUSTRY	31	1	86-88	92-94	98-00	1992	2	91	3
0021	U.S. EXERTS MILITARY FORCE IN DEFENSE OF THE PANAMA CANAL	31	1	89-91	95-97	01-03	1996	3	77	4
0056	ESTABLISHMENT OF TRANSPORTATION SYSTEM USING 1 M DWT TANKERS, SEABERTHS & OFFSHORE PETROLEUM TANKS	15	38	92-94	98-00	04-06	2000	4	27	5
0053	6 U.S. DEEPWATER PORTS ARE AVAILABLE TO HANDLE SUPERTANKERS CARRYING PETROLEUM (CRUDE & PRODUCTS)	11	49	89-91	92-94	95-97	1992	2	27	6
0037	SEVEN OFFSHORE NUCLEAR POWER PLANTS ARE OPERATIONAL IN U.S. WATERS	22	13	92-94	98-00	01-03	1999	3	20	7
0054	INSTALLATION OF 800-2700 MORE OIL/NATURAL GAS DRILLING OR PRODUCTION PLATFORMS ON THE U.S. OCS	24	9	86-88	92-94	95-97	1992	2	25	8
0027	THE GREAT LAKES ARE OPEN FOR INTRA-LAKE SHIPPING 12 MONTHS PER YEAR	17	30	83-85	86-88	92-94	1988	1	23	9
0046	U.S. ACTIVITY LEVELS IN POLAR REGIONS, FOR RESEARCH & NATURAL RESOURCE EXPLORATION, TRIPLE OVER 1975	20	19	83-85	89-91	95-97	1991	2	22	10
0039	THERE ARE 14 ATLANTIC OCS OIL DRILLING PLATFORMS WITH A TOTAL OF 240 OIL WELLS IN PLACE	22	13	86-88	92-94	98-00	1992	2	21	11
0019	200-MILE FISHERIES CONSERVATION ZONE BECOMES A 200-MILE EXCLUSIVE ECONOMIC ZONE	22	13	80-82	86-88	92-94	1988	1	18	12
0015	30% OF DOMESTIC PETROLEUM PRODUCTION COMES FROM OFFSHORE SOURCES	18	22	80-82	83-85	86-88	1985	1	17	13
0011	TWO TANKERS COLLIDE OFF DELAWARE CAPES	18	22	80-82	86-88	92-94	1986	1	17	14
0012	TANKER COLLIDES WITH U.S. OIL PLATFORM	21	17	80-82	86-88	92-94	1986	1	16	15
0038	THERE ARE 7 OCS OIL DRILLING PLATFORMS WITH A TOTAL OF 120 OIL WELLS IN PLACE IN THE GULF OF ALASKA	16	31	86-88	92-94	95-97	1992	2	16	16
0030	A TOWED UNDERWATER BULK CARGO VESSEL IS IN OPERATION	29	5	86-88	92-94	98-00	1993	2	16	17
0010	LNG TANKER EXPLODES OFF U.S. EAST COAST	31	1	83-85	89-91	98-00	1990	2	16	18
0008	TERRORIST GROUP COMMANDEERS AND HOLDS FOR RANSOM A FUEL SHIPMENT TO A FLOATING NUCLEAR POWER PLANT	16	34	92-94	98-00	01-03	1999	3	15	19
0018	COAST GUARD IS ASSIGNED PEACETIME FEDERAL OCS ASSET SECURITY RESPONSIBILITY OUTSIDE TERRITORIAL SEA	24	6	86-88	89-91	92-94	1989	1	15	20
0045	2-, 3-, AND 4-SEATER HOVERCRAFT COMPRISE 10% OF RECREATIONAL BOATS SOLD	25	7	86-88	95-97	98-00	1995	3	15	21
0036	TRANSPORTATION OF HAZARDOUS & TOXIC MATERIALS BY WATER INCREASES TO TWICE THE 1975 TONNAGE	16	31	83-85	86-88	92-94	1988	1	15	22
0014	THREE-SHIP COLLISION OCCURS OFF AMBROSE LIGHT (APPROACHES TO NEW YORK)	19	21	86-88	92-94	98-00	1992	2	14	23
0026	WORLDWIDE THERE ARE 25,000 VESSELS LARGER THAN 1000 GROSS TONS, A 23% INCREASE OVER 1975	23	10	86-88	92-94	98-00	1992	2	14	24
0032	PERMANENT UNDERSEA INSTALLATIONS ARE MANNED CONTINUOUSLY FOR COMMERCIAL ACTIVITY	22	12	83-85	89-91	95-97	1989	1	14	25
0028	THE UPPER REACHES OF THE MISSISSIPPI ARE OPEN FOR SHIPPING 12 MONTHS PER YEAR	13	47	86-88	92-94	98-00	1993	2	12	26
0031	MARICULTURE ACCOUNTS FOR 10% OF MARINE FOOD TAKEN FROM THE U.S. FISHERIES CONSERVATION ZONE	18	22	83-85	92-94	98-00	1992	2	11	27
0052	THE MEAN SIZE OF CRUDE OIL TANKERS IN USE EXCEEDS 100,000 DWT	15	38	86-88	92-94	95-97	1992	2	11	28
0022	WORLD PRODUCTION OF MARINE FOOD INCREASES BY 70% OVER 1975 LEVELS	16	22	89-91	95-97	01-03	1996	3	11	29
0058	OIL DRILLING RIGS ARE ESTABLISHED IN DEPTHS GREATER THAN 400 METERS	10	53	80-82	83-85	86-88	1984	1	11	30

KEY TO COLUMN HEADINGS

INITIAL WT. A — Relative importance of the event to the Coast Guard Objectives (See Table 5-3)

INITIAL RANK — Initial rank ordering of the events according to WT. A (See Table 5-3)

CUM. PROB. DATES — Cumulative Probability Dates indicate the three year period during which the probability the event occurs is 0.1, 0.5, 0.9 (See Appendix D).

TRIG DATES — Trigger Date is the year event probability equals 0.5 (See Appendix D).

SN — Scenes are defined as follows:

SCENE	TIME PERIOD
1	1980-1984
2	1985-1989
3	1990-1994
4	1995-1999
5	2000-2004

FINAL WT. B — Relative importance of the event to both the Coast Guard Objectives and surveillance requirements.

FINAL RANK — Final rank ordering of the events according to WT. B.

TABLE 7-3. (Continued).

EVNT	EVENT DESCRIPTION	INITIAL WT. A	INITIAL RANK	CUM. PROB. DATES (0.1)	CUM. PROB. DATES (0.5)	CUM. PROB. DATES (0.9)	TRIG DATE	SN	FINAL WT. B	FINAL RANK
0006	STABLE U.S. OCEAN PLATFORMS ARE USED AS SEA STATIONS FOR AIRPORTS, RESORTS, OR SHIPPING TERMINALS	20	19	86-88	92-94	96-00	1993	2	11	31
0009	MAJOR OIL SPILL FROM A VESSEL OCCURS IN LOWER CHESAPEAKE BAY	18	22	80-82	83-85	89-91	1985	1	10	32
0029	EXPORTS OF U.S. AGRICULTURAL PRODUCTS VIA GREAT LAKES PORTS INCREASES 50% OVER 1975 LEVELS	15	35	89-91	95-97	01-03	1996	3	10	33
0001	UNDERWATER PARKS WITH OBSERVATION POSTS, PROMENADES, MONORAILS AND SUBMARINE TOURIST VESSELS	16	31	86-88	89-91	95-97	1991	2	10	34
0040	12 U.S. OCEAN-THERMAL ENERGY PLANTS ARE OPERATIONAL	15	38	92-94	96-00	04-06	2000	4	9	35
0024	U.S. MERCHANT FLEET (LARGER THAN 5 GRT) WILL NUMBER 62,000 (20% INCREASE OVER 1975)	14	42	83-85	86-88	89-91	1987	1	8	36
0049	HOVERCRAFT ARE USED AS COMMERCIAL FERRIES FOR PASSENGERS AND AUTOS IN AT LEAST 5 STATES	15	35	83-85	89-91	95-97	1990	2	8	37
0022	MOST PETROLEUM (CRUDE & PRODUCTS) IMPORTED TO U.S. COMES IN SHIPS LARGER THAN 150,000 DWT	21	17	83-85	89-91	92-94	1989	1	8	38
0051	REGULATORY RESPONSIBILITY FOR SECURITY OF UNDERWATER OIL PIPELINES IS ASSIGNED TO THE COAST GUARD	11	51	80-82	83-85	89-91	1985	1	8	39
0013	MAJOR UNDERWATER OIL PIPELINE BREAK OCCURS	14	45	80-82	83-85	86-88	1984	1	7	40
0044	THERE ARE 150 CIVILIAN SUBMERSIBLES IN USE IN U. S. WATERS	12	48	83-85	89-91	92-94	1989	1	7	41
0059	LARGE AIR CUSHION VEHICLE FREIGHTERS WITH EITHER CHEMICAL OR NUCLEAR POWER CARRY OCEAN-GOING CARGO	15	38	98-00	01-03	04-06	2003	4	7	42
0035	A KELP FARM IS ESTABLISHED OFF THE COAST OF CALIFORNIA	22	13	80-82	86-88	89-91	1981	1	7	43
0032	IMPORTS FROM SINO-SOVIET BLOC NATIONS DOUBLE OVER 1975 LEVELS	14	42	80-82	86-88	89-91	1986	1	7	44
0060	DEVELOPMENT OF AT LEAST 1 COMMERCIAL SUBMARINE CARGO VESSEL IN THE 10,000 TON CLASS	23	10	89-91	98-00	01-03	1998	3	7	45
0033	A U.S. FLOATING PLANT IS ESTABLISHED TO EXTRACT MINERALS FROM SEA WATER	15	35	86-88	92-94	98-00	1993	2	7	46
0021	THE THIRD CIVILIAN SUBMERSIBLE SINKS, MAKING A TOTAL OF 15 LIVES LOST IN SUBMERSIBLE ACCIDENTS	18	28	80-82	86-88	89-91	1986	1	7	47
0041	FISH STOCKS ON THE ATLANTIC OCS ARE REPLETED TO 1960 LEVELS	11	49	89-91	92-94	95-97	1992	2	6	48
0007	THERE WILL BE MORE THAN 15 MILLION PLEASURE BOATS IN THE U.S.	14	42	86-88	92-94	95-97	1992	2	5	49
0016	DRIFTING BARGE COLLIDES WITH A FLOATING NUCLEAR POWER PLANT	18	22	92-94	96-00	04-06	1999	3	5	50
0017	MAJOR FIRE OCCURS ON OIL PLATFORM OFF NEW JERSEY	16	26	83-85	89-91	92-94	1991	2	5	51
0046	A LARGE TIDAL POWER PLANT IS IN OPERATION IN THE U.S.	11	51	92-94	96-00	04-06	1999	3	4	52
0030	NUCLEAR-POWERED SHIP SINKS ON OUTER CONTINENTAL SHELF	8	56	92-94	96-00	04-06	1999	3	4	53
0042	LAW OF THE SEA TREATY IS RATIFIED	14	45	86-88	92-94	95-97	1992	2	4	54
0047	COAL AND NUCLEAR PROPULSION PLANTS ARE USED IN 50% OF NEW SHIP CONSTRUCTION WORLD-WIDE	7	57	89-91	95-97	01-03	1996	3	3	55
0055	TWICE AS MANY LIGHTER-ABOARD SHIPS (LASH) ARE IN USE AS WERE IN 1975	9	55	86-88	95-97	98-00	1996	3	3	56
0057	AVERAGE SIZE OF OIL-BULK-ORE CARRIERS IN USE EXCEEDS 200,000 DWT	9	54	92-94	96-00	04-06	2000	4	2	57
0034	BILGE AND BALLAST PETROLEUM DUMPING IS VIRTUALLY ELIMINATED	1	58	86-88	92-94	96-00	1994	2	0	58
0003	EMERGENCY ALERTING & LOCATING DEVICES LEGALLY REQUIRED ON ALL US RECREATIONAL BOATS OVER 25 FT LONG	-9	59	83-85	86-88	92-94	1988	1	-2	59
0005	LOCATING DEVICES ARE REQUIRED TO BE CARRIED ABOARD ALL US & LICENSED FOREIGN FISHING VESSELS IN FCZ	-12	60	80-82	86-88	89-91	1986	1	-5	60

KEY TO COLUMN HEADINGS

INITIAL WT. A — Relative importance of the event to the Coast Guard Objectives (See Table 5-3)

INITIAL RANK — Initial rank ordering of the events according to WT. A (See Table 5-3)

CUM. PROB. DATES — Cumulative Probability Dates indicate the three year period during which the probability the event occurs is 0.1, 0.5, 0.9 (See Appendix D).

TRIG DATES — Trigger Date is the year event probability equals 0.5 (See Appendix D).

SN — Scenes are defined as follows:

SCENE	TIME PERIOD
1	1980-1984
2	1985-1989
3	1990-1994
4	1995-1999
5	2000-2004

FINAL WT. B — Relative importance of the event to both the Coast Guard Objectives and surveillance requirements.

FINAL RANK — Final rank ordering of the events according to WT. B.

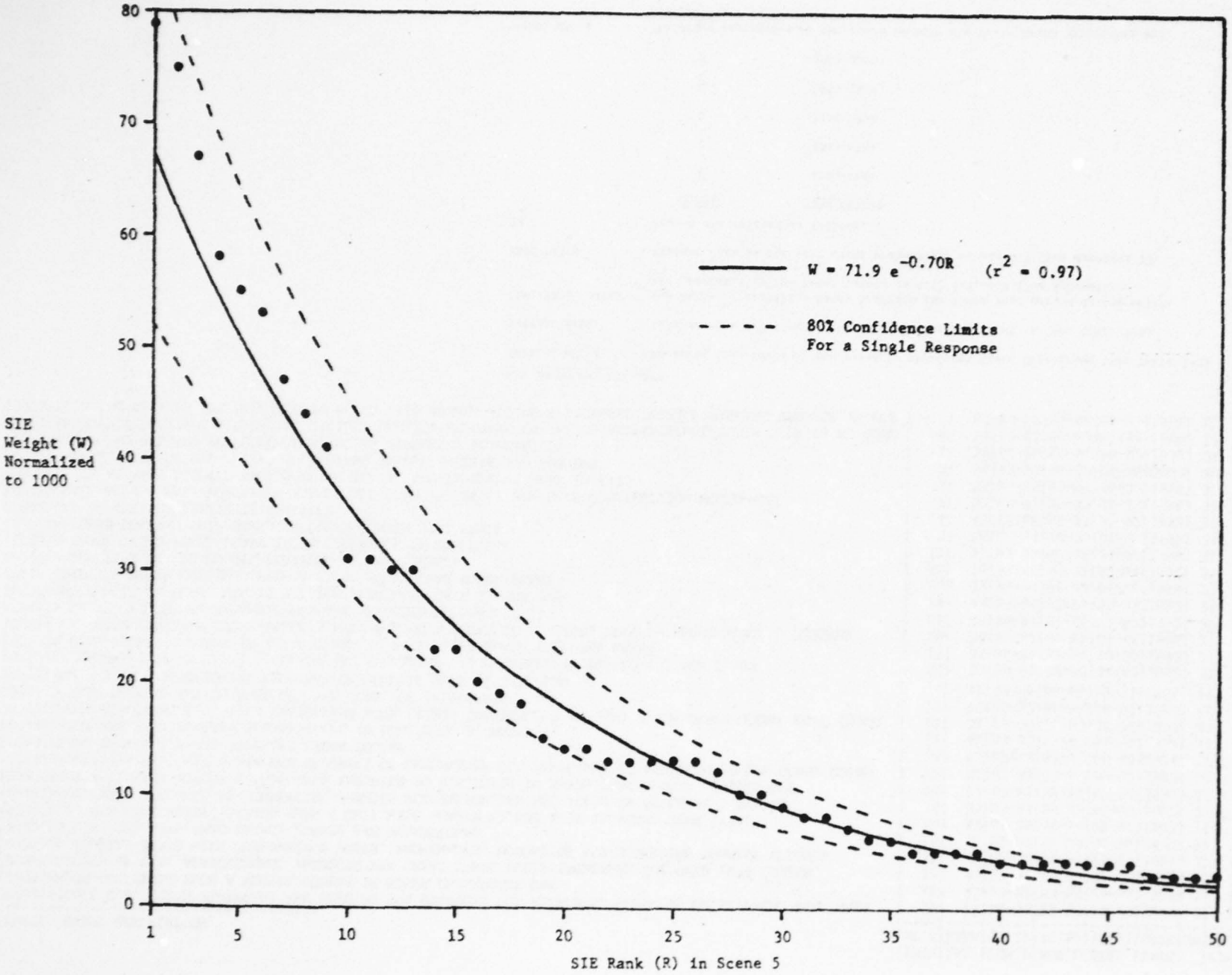


FIGURE 7-2. SIE WEIGHTS vs. RANKS IN SCENE 5

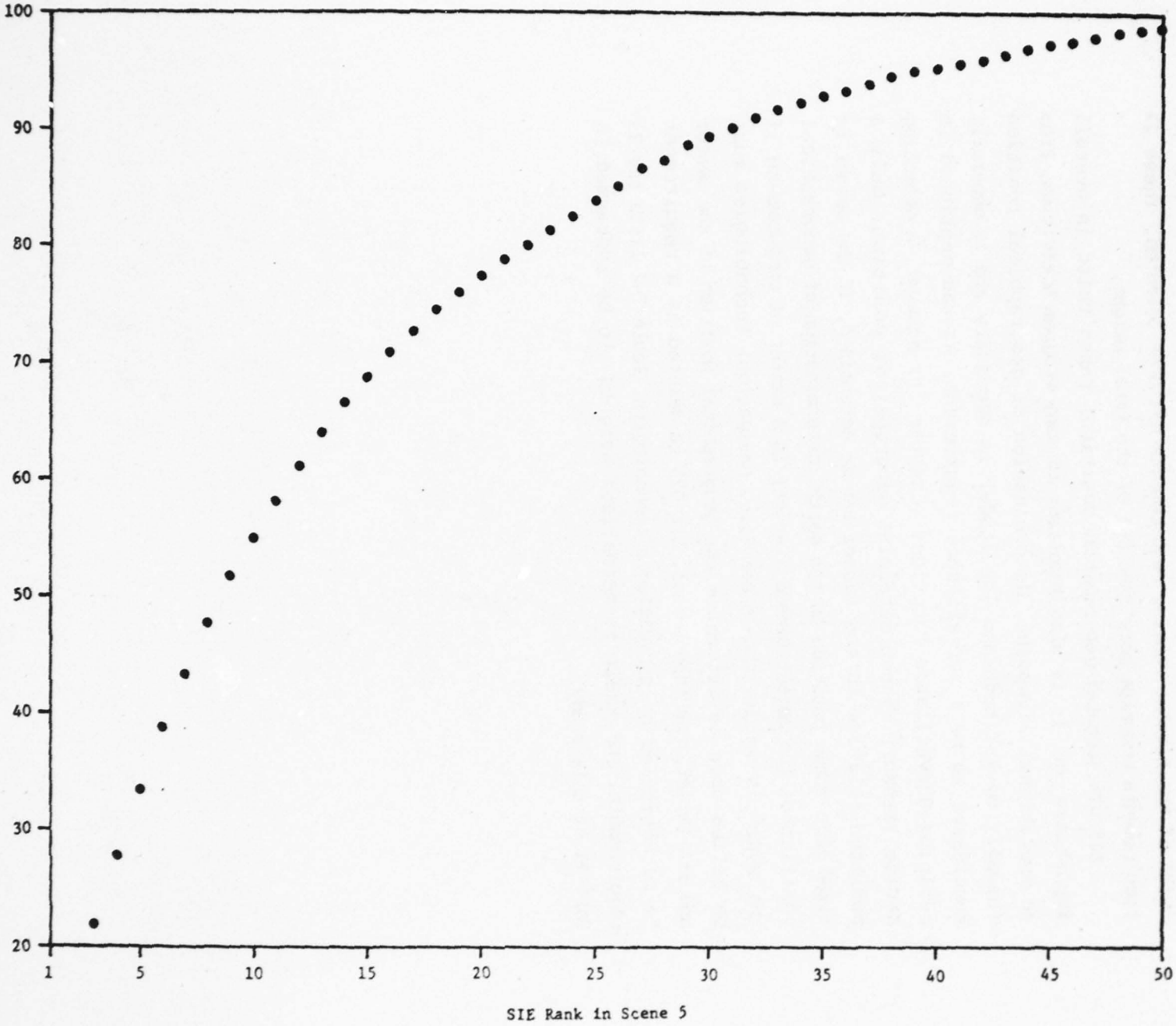


FIGURE 7-3. SIE RANKS AS A PERCENTAGE OF TOTAL WEIGHT

analyzing only the more significant requirements. Accordingly, one third of the highest ranking requirements has been selected. These 24 requirements comprise more than 80% of the total weight.

SIE 025 (Locate: geographical position) ranks third in overall importance and it is also important to many Program Activities. From an operational viewpoint, determination of geographical position (usually by latitude and longitude) is necessary and is generally considered to be a surveillance requirement. As was mentioned in defining Surveillance Functions (Chapter 3), however, a detecting device (sensor) cannot determine geographical position; only a position relative to the sensor can be determined. If the sensor is fixed to a known position on the earth, determination of geographical position of the object sensed (target) is a matter of computation; if the sensor is mobile, then other (i.e. navigation) technologies must be called upon to determine the geographical position of the sensor and its target. For this reason, SIE 025 is deleted as a requirement to be satisfied by surveillance technologies. Table 7-4 lists the 23 requirements, and their re-normalized weights, to be addressed in Part II of this study.

TABLE 7-4. SURVEILLANCE REQUIREMENTS SELECTED FOR FURTHER ANALYSIS

SIE	SURVEILLANCE FUNCTION AND SIE DESCRIPTION	NORMALIZED WEIGHTS			
		SCENE 1		SCENE 5	
		INITIAL[a]	FINAL	INITIAL[a]	FINAL
023	LOCATE: RANGE AND BEARING	66	91	79	104
004	DETECT: SMALL VESSEL (16'-40'), METAL BUOY, BEACON, ICEBERG, AFLOAT SEAPLANE	47	65	75	99
025	LOCATE: GEOGRAPHICAL POSITION		DELETED		
034	OBSERVE: STRUCTURAL INTEGRITY	83	115	58	76
037	OBSERVE: MOVEMENT OF OBJECT OF INTEREST	54	75	55	72
003	DETECT: MEDIUM SIZED VESSEL (40'-150')	47	65	53	70
002	DETECT: LARGE VESSEL (150'+)	38	53	47	62
029	IDENTIFY: TYPE	40	55	44	58
047	OBSERVE: HAZARDOUS ACTIVITY	34	47	41	54
024	LOCATE: ALTITUDE OR DEPTH	41	57	31	41
026	IDENTIFY: NAME OR IDENTIFYING NUMBER	32	44	31	41
005	DETECT: SWIMMER, NON-METAL BUOY, FISH TRAP MARKER, GROWLER, DITCHED AIRCRAFT	29	40	30	40
046	OBSERVE: HOSTILE ACTIVITY	17	24	30	40
033	IDENTIFY: CHARACTERISTIC CODE	20	28	23	30
013	DETECT: LIQUID POLLUTANT	46	64	23	30
019	DETECT: SOUND EMISSION IN AIR	14	19	20	26
030	IDENTIFY: COLOR	20	28	19	25
018	DETECT: ELECTROMAGNETIC EMISSION: LIGHT (400-750 THZ) (0.75-0.4 MICRON)	14	19	18	24
022	LOCATE: RANGE OR BEARING	13	18	15	20
038	OBSERVE: TRANSMISSION TIME SCHEDULE	14	19	14	18
021	DETECT: NUCLEAR RADIATION: ALPHA AND BETA PARTICLES, GAMMA RAYS	23	32	14	18
008	DETECT: DIVER (UNDERWATER SWIMMER)	15	21	13	17
015	DETECT: ELECTROMAGNETIC EMISSION: RADIO (10 KHZ-30 GHZ)	3	4	13	17
027	IDENTIFY: FLAG (U.S. OR FOREIGN)	13	18	13	17
		723	1001[b]	759	999[b]

[a] From Table 7-2.

[b] Totals do not sum to 1000 due to rounding errors.

Part II - SURVEILLANCE TECHNOLOGIES

CHAPTER 8 - OVERVIEW OF TECHNOLOGIES VS. REQUIREMENTS ANALYSIS

Part I of this study addressed future Coast Guard surveillance requirements without regard to the technologies necessary to satisfy those requirements. Part II investigates current and emerging technologies which may be applied to solve surveillance problems. The purpose of this chapter is to outline broadly the approach taken to identify relevant technologies and to assess their relative merit or value in satisfying future Coast Guard surveillance requirements. Figure 8-1 is a flow chart of the process.

Starting with a literature search, a list of technologies useful to the analysis is developed. These technologies are described in sufficient detail to establish broad capabilities and limitations. Surveillance systems derived from, or based on, these technologies are similarly described, together with a directory of developers. The discussion of technologies has been kept unclassified wherever possible; classified material has been placed in a separately bound volume (Volume 3).

A Surveillance Technologies model is described in Chapter 10. This model consists of a technology scoring model, two cross-relevance matrices, and a gap diagram. The maturity (position on a typical growth curve) of each technology is assessed in the scoring model. The weighted technologies from the scoring model are used as inputs to both cross-relevance matrices. The weights of the highest ranking requirements, from Part I, provide the second cross-relevance argument. The cells or row/column intersections of the cross-relevance matrices contain quantified judgments of the effectiveness of each technology in satisfying each requirement. A gap or difference between what is potentially possible on one hand, and what is currently applied on the other, is produced by comparing the outputs of the two cross-relevance matrices. This information is

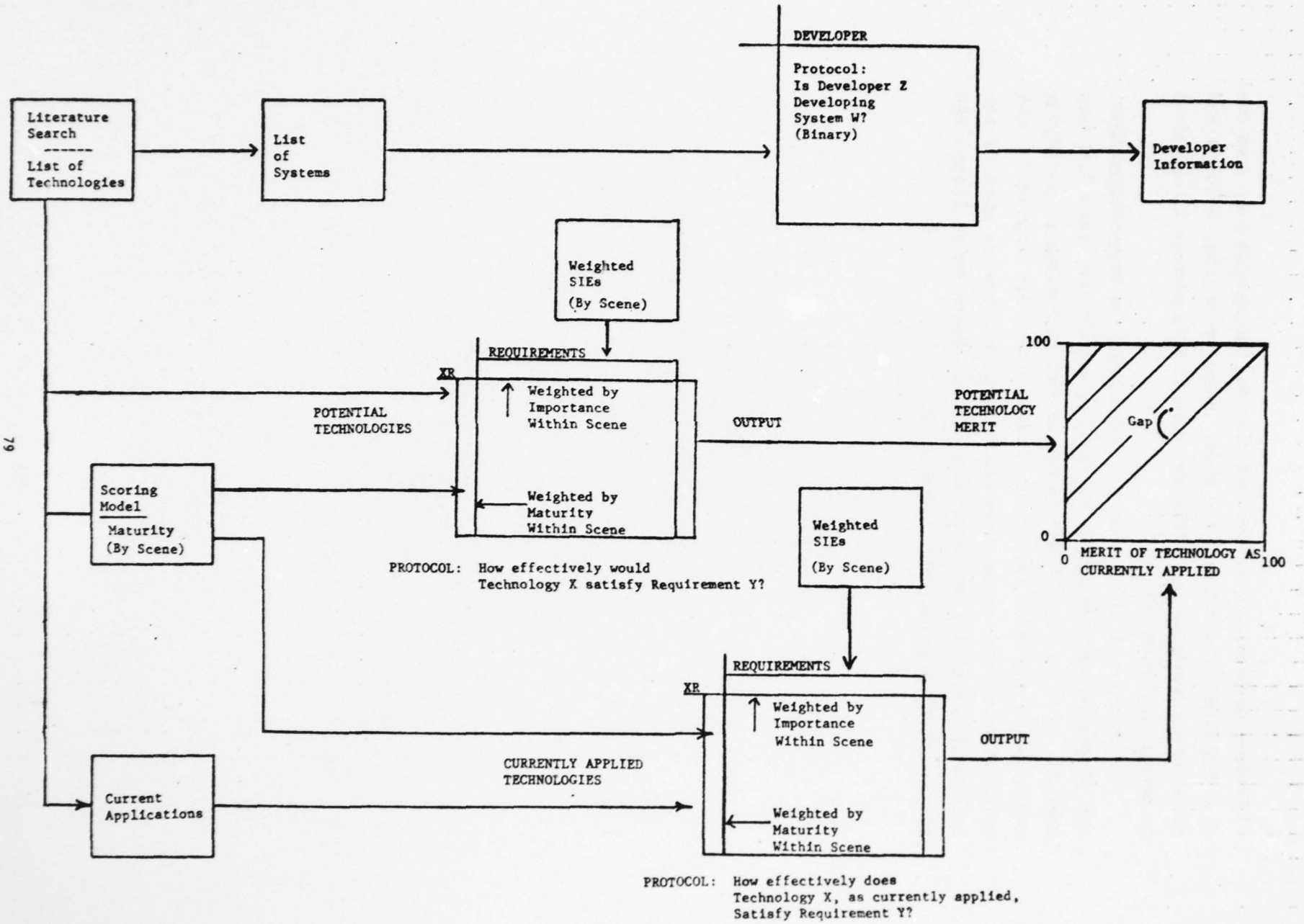


FIGURE 8-1. FLOW CHART OF TECHNOLOGY ANALYSIS

displayed graphically in the gap diagram. Gap changes over time are also displayed by exercising the model using technology weights and requirement weights for different scenes. This process is explained in detail in Chapter 10.

In Chapter 11 the results of exercising the Technologies Model are displayed and analyzed. By ranking technology gaps and gap changes, the relative effectiveness of each technology in satisfying Coast Guard surveillance requirements is made explicit. The conclusions drawn from this gap assessment provide much of the information necessary for developing a Coast Guard surveillance R&D program which is presented in Chapter 12.

CHAPTER 9 - SURVEILLANCE TECHNOLOGIES

The List of Technologies. Technologies currently used for surveillance purposes have been identified by surveying literature and reports relating to surveillance and targeting, by tapping the experience of analysts and engineers in Forecasting International, and by communications with knowledgeable scientists and engineers in pertinent fields. Surveillance and targeting in land, sea and air operations in the military and naval services are vital capabilities and are actively under research and development.

Current technologies include electromagnetic, magnetic, acoustic, chemical, nuclear, mechanical, and thermal. These are broad categories and somewhat difficult, in some instances, to evaluate against the needs of surveillance. Several iterations of the technologies list were tried before finally settling on the list given in Table 9-1 and described below. A more detailed list of technologies, reaching into more specific systems, can be constructed, but it then becomes difficult, because of size, to evaluate against the list of surveillance requirements. It also becomes unproductive for purposes of this study because the more specific the list becomes, the more dated the system and technology being considered becomes. In other words, to gain a perspective of the future longer than 5 or 10 years, technologies rather than systems must be considered.

The technology list used is given below with a short resume to characterize the technology field. The usual ancilliary devices and techniques (for signal processing, for instance) have been assumed to be a part of the conceptual system for evaluating the technology against present and future needs.

Acoustics, air - Includes all sensible detection of sound in air with or without mechanical and or electrical aids. No specific frequency limits were considered.

TABLE 9-1. TECHNOLOGIES LIST

1 - Air Acoustics

2 - SONAR, Passive

3 - SONAR, Active

4 - Magnetic Field

5 - Radio Frequency

6 - Electromagnetic Field

7 - RADAR, Over-the-Horizon

8 - RADAR, Medium Range

9 - RADAR, Millimeter

10 - Infrared

11 - Television

12 - Optical

13 - Photography

14 - Image Intensification

15 - LASER, Blue-Green

16 - LASER, Other

17 - Ultraviolet

18 - Nuclear

19 - Chemical

20 - Animal (Bird)

21 - Acoustic Emission

22 - Mechanical Vibration

Sonar, passive - (Sound Navigation and Ranging) Includes acoustic or sonic and supersonic detection in water. No specific frequency limits were considered.

Sonar, active - Includes acoustic or sonic and supersonic generation and detection in water. No frequency limits were considered.

Magnetic field - This technology consists of detecting magnetic properties of bodies or variations and anomalies in the earth's magnetic field caused by the presence of a magnetic material.

Radio Frequency - Techniques and systems which detect electromagnetic radiation below the 1 GHz frequencies.

Electromagnetic field - This technology includes detection and analysis of the electromagnetic spectrum from 1 to 100 GHz but no specific limits were considered to be firm. The radio frequency spectrum below 1 GHz was considered to belong to Radio Frequency Technology.

Radar, over-the-horizon - This is radar using refraction and reflection from ionic layers for projection of radiation over the horizon and return of reflected energy for detection.

Radar, medium range - This is conventional radar and the usual frequencies include 100 MHz to 12 GHz. It is characterized by ranges up to about 250 miles but essentially line of sight performance.

Radar, millimeter - Includes electromagnetic transmission and detection for ranging. The usual frequencies include 10-100 GHz. It is characterized by short (10 mile) ranges but very high resolution and line of sight performance.

Infrared - Techniques and systems which detect and record or display

	images portrayed by infrared radiation.
Television -	Includes present conventional television techniques and systems including the combinations called low light level TV systems.
Optical	Includes visible light transmission and detection by the human eye assisted or unassisted by lenses and other passive devices.
Photography -	Includes all techniques for recording on suitably prepared paper or film images and ultra or sub visible range spectra.
Image Intensification -	Techniques and devices which magnify or intensify light from its image to distinguish it from its background, usually by cascading electronic phenomena.
Laser, Blue-Green	Consists of a laser techniques and systems operating in the 4500 to 5500 A range, which is the range which has the least absorption in water.
Laser, other -	A light laser system of any wavelength other than the blue-green.
Ultraviolet -	Techniques and systems which detect and/or record or display images portrayed by ultraviolet radiation.
Nuclear -	Techniques and systems which detect and measure alpha or beta particles, or gamma rays and also other types of nuclear radiation as feasible.
Chemical -	Techniques and systems which detect and identify gaseous, liquid or solid compounds and also measure pressure, temperature, acidity, basicity, etc. Includes gas chromatography, mass spectroscopy, etc.

Animal (Bird) - Techniques for harnessing, within trainability limits, the natural surveillance capabilities (notably visual activity) of birds.

Acoustic Emission - Techniques and systems which detect and measure transient elastic waves generated by discontinuities within a material or structure under stress.

Mechanical Vibration - Techniques and systems which detect and measure the natural vibration of a structure under stress.

Technology Evaluation. To consolidate and amplify information gained through literature searches an all day meeting of knowledgeable FI staff members and consultants was held on February 1, 1979, during which the technology list was evaluated, and the present state of development and capability of each technology were reviewed. The projected capabilities of the technologies were considered and developing laboratories were identified. Consideration was also given to the projected versatility of each technology, i.e., any limitations concerning the platforms (ships, boats, aircraft, etc.) on which future systems based on the technology might be mounted. These discussions are summarized in Appendix J. Development considerations not directly related to specific technologies were also raised. These are summarized in Appendix K.

Figure 9-1 shows a technology scoring model which was presented to the panel of experts. The specific procedure to establish weights for each of the technologies was based upon the development of a generalized S-shaped growth curve and the partitioning of that growth curve into four distinct segments. The first segment (A, the lower left hand portion of the S curve) is concerned with the early stages of the development of any particular technology - this area would be referred to as the new or initial growth portion of the specific technology. Somewhere between the 10 and 20% point the second stage (B) begins and continues until we reach the inflection point of the S curve. This segment of the curve represents the initial or lower half of the rapid growth portion of the technology.

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A STUDY OF USCG SURVEILLANCE REQUIREMENTS OVER THE NEXT 25 YEAR--ETC(U)
APR 79 M J CETRON, C F MCFADDEN, O H LANDUA DOT-CG-836036-A
UNCLASSIFIED USCG-D-10-79-VOL-1 NL

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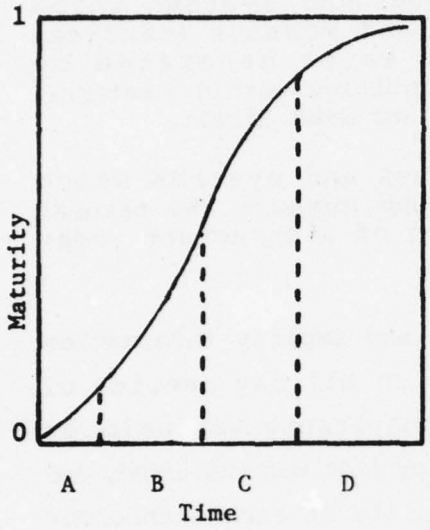
SCORING MODEL

Technology: _____

Estimate the maturity of the technology (position on a typical growth curve) in 1980 and 2000.



GRAPH ZONE	GROWTH DESCRIPTOR	SCORE
A	Newborn	1
B	Early Rapid Growth	2
C	Late Rapid Growth	4
D	Mature	8

Zone in 1980 _____

Zone in 2000 _____

SUMMARY

		Scene 1			Scene 5		
	Technology	Graph Zone	Score	Normal Weight	Graph Zone	Score	Normal Weight
1.	Air Acoustic	D	8	78	D	8	70
2.	Sonar, Passive	B	2	19	C	4	35
3.	Sonar, Active	C	4	39	C	4	35
4.	Magnetic Field	C	4	39	C	4	35
5.	Radio Frequency	D	8	78	D	8	70
6.	Electromagnetic Field	C	4	39	C	4	35
7.	Radar, OTH	A	1	10	B	2	18
8.	Radar, Med. Range	C	4	39	C	4	35
9.	Radar, Millimeter	B	2	19	C	4	35
10.	Infrared	C	4	39	C	4	35
11.	Television	D	8	78	D	8	70
12.	Optical	D	8	78	D	8	70
13.	Photography	D	8	78	D	8	70
14.	Image Intensification	C	4	39	C	4	35
15.	Laser, Blue-Green	B	2	19	B	2	18
16.	Laser, Other	B	2	19	B	2	18
17.	Ultraviolet	D	8	78	D	8	70
18.	Nuclear	D	8	78	D	8	70
19.	Chemical	D	8	78	D	8	70
20.	Animal (Birds)	B	2	19	C	4	35
21.	Acoustic Emission	B	2	19	C	4	35
22.	Mechanical Vibration	B	2	19	C	4	35
	TOTAL*			1,001			999

*Does not sum to 1,000 due to rounding errors.

FIGURE 9-1. TECHNOLOGY SCORING MODEL AND RESULTS

The third portion (C) begins at the inflection point and rises to the 80 or 90% level where the technology begins to mature and its growth rate is significantly reduced. This third segment is the upper portion of rapid growth phase of the technology. The final segment of the curve (D) represents the saturation or the very slow growth portion of the technology, the mature era of the technology being considered.

The panel was asked to estimate where, on a typical growth curve, each technology would lie in 1980 and in 2000 (i.e., Scene 1 and Scene 5). As shown in the figure, those technologies plotting high on the growth curve, in the region termed "mature", were scored high (8), whereas newborn technologies were scored low (1). The position on a typical growth curve, or maturity, was chosen as a surrogate for a risk estimate, reasoning that smaller technical risk is attached to mature technologies. The results of the panel's assessments are also shown in Figure 9-1, where normalized weights are given for both Scene 1 and Scene 5. This table provides the technology weights necessary for the Surveillance Technologies Model developed in Chapter 10.

Emerging Surveillance Systems. The results of the literature search for systems which will become available in the near term are given in Appendix L. Each system or equipment is described briefly with its capabilities, its state of development and its developer/supplier. It is evident that there is abundant technology available from which to choose.

No technology by itself is as effective as a combination of technologies and techniques. The combination gives a synergistic effect so that the capability of the combination exceeds the sum of capabilities of each technology applied separately. An example of this is the AIREYE system for detecting and evaluating oil slicks. The radar system might be able to locate an oil slick, but used in conjunction with the FLIR (infrared) and UV (ultraviolet) scanner more information is available, thereby permitting a more intelligent and accurate assessment to be made.

CHAPTER 10. SURVEILLANCE TECHNOLOGIES MODEL

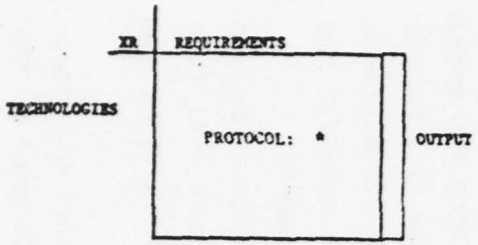
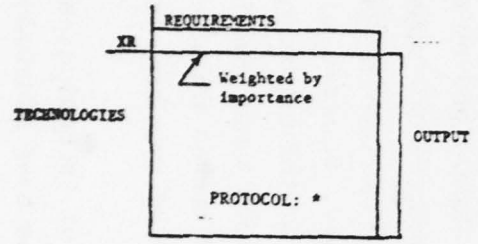
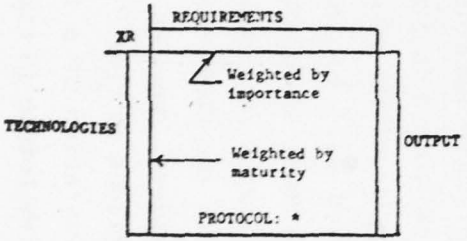
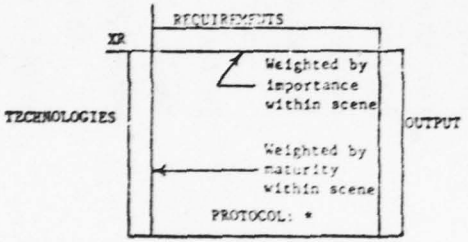
The purpose of this chapter is to describe in detail the mechanism by which the surveillance technologies identified in Chapter 9 are played against the surveillance requirements developed in Part I to provide a normative approach to structuring a surveillance R&D program. Reference is again made to Figure 8-1 which outlines the process.

The Technologies Model focuses on matters of importance to a Coast Guard surveillance R&D program; a technology is considered to be important to the R&D program if:

- The technologies in use do not or will not adequately satisfy near or long term future surveillance requirements.
- The technology could contribute significantly to satisfaction of future surveillance requirements.
- The technical development risk for an evolving technology is relatively low.

To meet these criteria the model outputs must show the relative merit (value or importance) of the technologies considered as well as the gap between the foreseeable potential merit of the technologies and the merit of the technologies as currently applied. Two cross-relevance models, one for potential technologies and the other for technologies as currently applied, have been chosen to provide these outputs.

The development of the cross-relevance models for the present application is outlined in Figure 10-1. In its simplest form (Stage 1), technologies are arrayed against requirements in matrix form so that pair-wise comparisons of each technology against each requirement can be made systematically. Comparisons are made by a panel of experts according to the protocol: How effectively would Technology X satisfy Requirement Y? Descriptive and numeric responses are elicited as follows:

		MODEL OUTPUT (Technology Merit)	ASSUMPTIONS IMPLICIT IN THE MODEL
STAGE 1		Suitability measure of how well each technology could satisfy each/all requirement(s).	o All requirements are equally important o All technologies are at the same state of development o Time independence
STAGE 2		Suitability measure of how important each technology is in satisfying each/all requirement(s).	o All technologies are at the same state of development o Time independence
STAGE 3		Suitability and technical feasibility measure of how important each technology is in satisfying each/all requirement(s).	o Time independence
STAGE 4		Suitability and technical feasibility measure of how important each technology is in satisfying each/all requirement(s) in each scene.	o None

*PROTOCOL: How effectively would Technology X satisfy Requirement Y?

FIGURE 10-1. CROSS-RELEVANCE MODEL DEVELOPMENT

0 implies no effectiveness

1 implies barely significant effectiveness

2 implies low effectiveness

4 implies moderate effectiveness

8 implies high effectiveness

By summing the scores for each matrix row, a numerical value for each technology is obtained in the output. The Stage 1 model, however, has several shortcomings: it assumes all requirements are equally important; it assumes all technologies are equally feasible; and it provides no way to show the effects of time on either the requirements or the technologies.

In Stages 2, 3 and 4 the assumptions cited above are successively relaxed. The Stage 2 model allows requirements to be weighted by importance. In this stage the merit of each technology is found by summing the products of the cell values times their respective requirement weights.

In the Stage 3 model, each technology is also weighted to reflect its state of development. The merit of each technology becomes the sum of the products of cell value times its respective requirement weight and technology weight.

In the Stage 4 model, the last assumption (time independence) is relaxed by expressing requirement weights and technology weights for two different points in time. It is the Stage 4 version which is used in the Surveillance Technologies Model, and by exercising the model for these two points in time, measures of changes in the existing and potential applicability of surveillance technologies to surveillance requirements will be obtained. Sources of input data for the Technologies Model are discussed in the following paragraphs.

Surveillance requirements with their associated weights (derived in Part I) for the first and last scenes are given in Table 7-4. This table, therefore, provides a set of requirements with weights for two points or periods in time.

The generation of a list of technologies together with their weights at two points in time has been discussed in Chapter 9. The result of the panel's assessments are shown in Figure 9-1, where normalized weights are given for both Scene 1 and Scene 5.

Consequently, this table provides the technology weights necessary for the Surveillance Technologies Model.

Having obtained requirement weights and technology weights for Scene 1 and Scene 5, the panel of experts mentioned above was asked to estimate how effectively each technology would satisfy each requirement. These quantified judgments, the cell values, satisfy the last input data requirement for exercising the cross-relevance model for potential technologies (refer to Figure 8-1).

The cross-relevance model just described produces the relative potential merit of each technology. (A mathematical description of the cross-relevance model is given in Figure 10-2). In order to expose the technology gap upon which to predicate an R&D program, the technologies as currently applied in the Coast Guard have also been investigated using the second cross-relevance matrix shown in Figure 8-1. The objective at this point is to determine which technologies are currently employed by the Coast Guard and how well they satisfy surveillance requirements. In making this assessment, available Coast Guard literature[1] was searched to identify the technologies being applied. The efficacy or field usefulness of applied technologies (i.e., their derivative systems) in satisfying surveillance requirements was then drawn from various reports, briefings, and the personal experience of FT staff members.

The assessment was not concerned with how widespread the application might be. For instance, the effectiveness of medium-range radar, as currently applied, to satisfy a requirement to detect an aircraft would be evaluated as some positive number, even though only High Endurance Cutters are equipped with air search radars. In other words, even if only one system or equipment is employed in the field, the technology on which that system or equipment is based was considered to be currently applied, on the premise that the R&D effort necessary to field more such systems or equipment would be minimal. The cross-relevance model produces values of relative merit for the technologies as currently applied.

It should be noted that the cell values (the 0, 1, 2, 4, 8 technology assessments shown in Appendix M) in each pair of cross-relevance models do not change from scene to scene, i.e., there

RELATIVE IMPORTANCE (MERIT) OF ANY TECHNOLOGY

$$M_{ik} = W_{ik} \sum_{j=1}^{23} R_{jk} \cdot E_{ij} \qquad \text{for } i = 1, 2, \ldots, 22;\ k = 1, 5.$$

RELATIVE DEPENDENCE OF ANY REQUIREMENT

$$D_{jk} = R_{jk} \sum_{i=1}^{22} W_{ik} \cdot E_{ij} \qquad \text{for } j = 1, 2, \ldots, 23;\ k = 1, 5.$$

Where

D_{jk} is the total relative dependence of Requirement j on the effectiveness of all technologies in Scene k.

E_{ij} is an estimate of the effectiveness of Technology i in satisfying Requirement j, where

$E_{ij} = 0$ implies zero effectiveness

1 implies barely significant effectiveness

2 implies low effectiveness

4 implies moderate effectiveness

8 implies high effectiveness

M_{ik} is the total relative merit of Technology i in satisfying all requirements in Scene k.

R_{jk} is the relative weight for Requirement j in Scene k normalized to 100 (refer to Table 7-4).

W_{ik} is the relative weight for Technology i in Scene k normalized to 100 (refer to Figure 9-1).

i is the index of the set of technologies, i = 1, 2,...,22. (Refer to Table 9-1).

j is the index of the set of requirements, j = 1, 2,...,23. (Refer to Table 7-4).

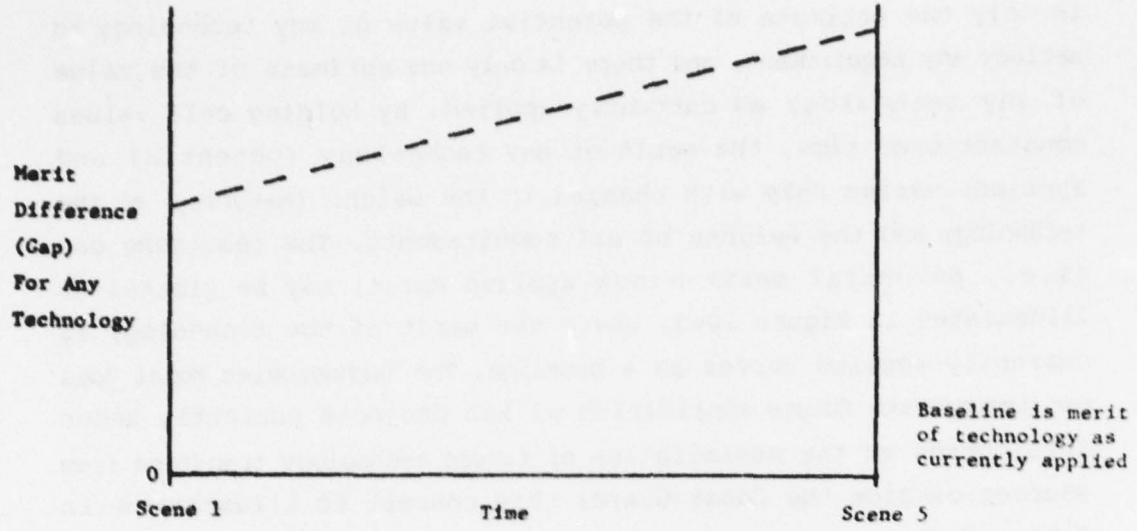
k is the index of the set of scenes, k = 1, 5, where k = 1 implies 1980-1984

5 implies 2000-2004

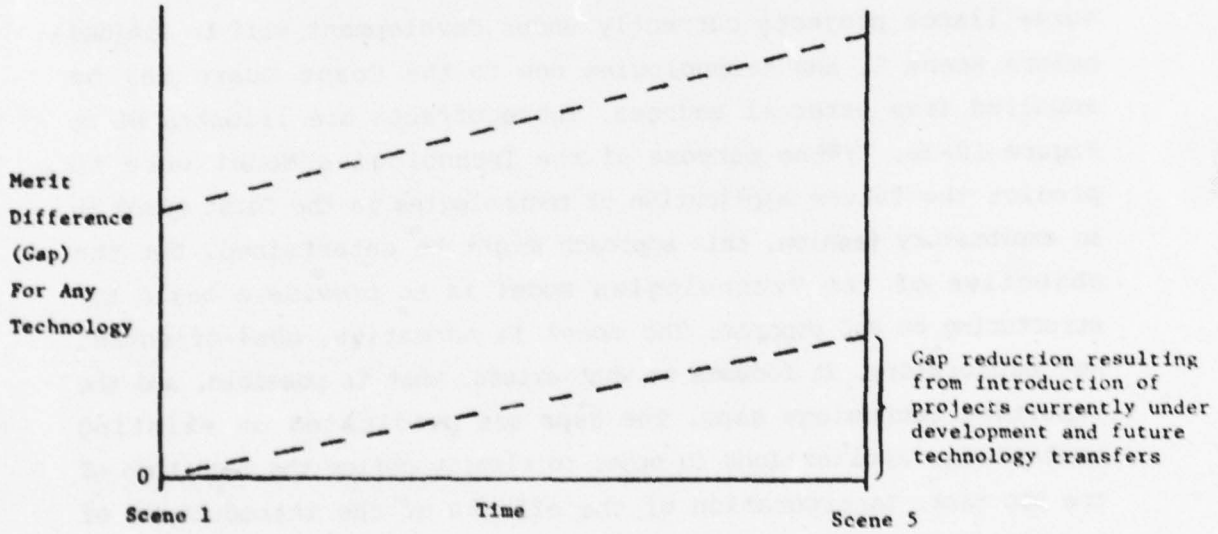
FIGURE 10-2. CROSS-RELEVANCE MATHEMATICAL MODEL

is only one estimate of the potential value of any technology to satisfy any requirement, and there is only one estimate of the value of any technology as currently applied. By holding cell values constant over time, the merit of any technology (potential and applied) varies only with changes in the weight (maturity) of the technology and the weights of all requirements. The resulting gap (i.e., potential merit minus applied merit) may be plotted as illustrated in Figure 10-3, where the merit of the technology as currently applied serves as a baseline. The Technologies Model does not incorporate future application of R&D projects currently under development or the assimilation of future technology transfers from sources outside the Coast Guard; this concept is illustrated in Figure 10-3a.

The validity and usefulness of holding matrix cell values constant over time, as discussed above, may be challenged. With regard to potential technologies, no other course is open; technology assessments are contingent on the knowledge base and the panel has given its best estimates based on today's knowledge. With regard to applied technologies, however, there is an alternative in that R&D surveillance projects currently under development will be fielded before Scene 5, and technologies new to the Coast Guard may be acquired from external sources. These effects are illustrated in Figure 10-3b. If the purpose of the Technologies Model were to predict the future application of technologies in the Coast Guard in an exploratory fashion, this approach might be entertained, but the objective of the Technologies Model is to provide a basis for structuring an R&D program. The model is normative, goal-oriented, not exploratory. It focuses on what exists, what is possible, and the resulting technology gaps. The gaps are predicated on existing technoloogy applications in order to clearly define the magnitude of the R&D task. Incorporation of the effects of the introduction of current R&D projects and technology transfers into the Scene 5 assessment could be deceptive because the Scene 5 gaps would mask a certain future R&D effort necessary to achieve a change in the applied merit, and also because any technology introductions postulated might not occur when, or with the effect, anticipated.



a. Future application of current R&D projects and assimilation of future technology transfers not considered.



b. Effect of incorporating current R&D projects and assimilating future technology transfers.

FIGURE 10-3. ILLUSTRATIVE GAP FOR ANY TECHNOLOGY

Fundamentally, however, any augmentation of currently applied technologies in the Technologies Model subverts the planning process, i.e., it is the purpose of the plan to assure that new technologies are introduced where most needed; new technologies will only be introduced as a result of some measure of R&D effort, and it is that effort which the plan should marshal and direct. For these reasons the concept illustrated in Figure 10-3b is rejected in favor of that shown in Figure 10-3a.

With the outputs of both cross-relevance models at hand, it is possible to display the results on a gap diagram. The potential merit of the technologies is plotted on the ordinate, and the merit of technologies as currently applied is plotted on the abscissa. Within any scene, each technology plots as a point on this diagram. The point must lie on or above the diagonal running from upper right to lower left, and the vertical or horizontal distance from the point to the diagonal is a measure of the technology gap. By plotting each technology for both scenes on the same diagram, and drawing a vector from the Scene 1 position to the Scene 5 position, the time change in the merit of any technology may be seen. In interpreting this display, the meaning of technology merit must be constantly borne in mind. Recall that because of the cross-relevance model inputs, the merit of any technology incorporates its maturity, its effectiveness in satisfying all requirements, and the relative importance of those requirements. Changes in any one or more of these factors with time can cause the point to move from scene to scene.

The gap diagram completes the Surveillance Technologies Model. The model has been constructed to satisfy the criteria for a surveillance R&D program by providing outputs which show the relative merit of each technology and where technology gaps exist. The model results are presented in Chapter 11 together with an interpretation of their significance for the surveillance R&D program.

NOTES FOR CHAPTER 10

1. Principally References 44, 46, 48.

CHAPTER 11 - MODEL RESULTS AND GAP ANALYSIS

The Technologies Model has been developed and exercised as described in Chapter 10. Analyses of the cross-relevance models which constitute the Technologies Model are given in detail in Appendix M. Here the weighted technologies, weighted requirements, matrix cell values, cell products, and totals may be seen for the four models (Potential Technologies in Scenes 1 and 5, Applied Technologies in Scenes 1 and 5).

Table 11-1 summarizes the results of these analyses. For each scene, merit values (row totals from the cross-relevance models divided by 10,000) for potential and applied technologies are shown, together with each technology gap (potential merit minus applied merit). Technology gaps are also ranked. In addition, the gap changes from Scene 1 to Scene 5 are given in terms of magnitude (Scene 5 gap minus Scene 1 gap), direction (gap opening (increasing), or closing), and rank. Ranking is treated algebraically in that an opening gap implies a positive value, and a closing gap implies a negative value. Gap and gap change ranks are intended to indicate the relative importance of the associated technologies for consideration in a Coast Guard surveillance R&D program.

Figure 11-1 is a parametric display (Technology Gap Diagram based on the data in Table 11-1) which indicates the merit of the potential technology in relation to the merit of the technology as currently applied for each of the 22 technologies and 23 requirements examined. In particular, the tail of each vector represents the values calculated in the two cross-relevance models for the initial time period (Scene 1: 1980-1984). The head of each vector represents the analogous values for the fifth time period (Scene 5: 2000-2004). Because matrix cell values are held constant over time, the vectors represent the combined effect of changes in technology weights (i.e., maturity) and surveillance requirement weights in the interval from Scene 1 to Scene 5. It should be noted that the technologies

TABLE 11-1. TECHNOLOGY GAPS AND GAP CHANGES

	Technology	Scene 1 (1980-1984) Merit[a] Potential	Applied	Gap	Rank	Scene 5 (2000-2004) Merit[a] Potential	Applied	Gap	Rank	Scene 5 - Scene 1 Gap Change Magnitude	Direction	Rank
1.	Air Acoustics	10.8	6.5	4.3	12	11.0	6.5	4.5	13	0.2	Opening	13
2.	SONAR, Passive	4.0	0	4.0	13	8.4	0	8.4	6	4.4	Opening	3
3.	SONAR, Active	12.7	8.9	3.8	14	12.0	8.7	3.3	16	0.5	Closing	19
4.	Magnetic Field	3.6	0	3.6	15	3.7	0	3.7	14	0.1	Opening	14
5.	Radio Frequency	20.3	7.9	12.4	2	22.5	8.6	13.9	3	1.5	Opening	6
6.	Electromagnetic Field	10.1	6.9	3.2	18	11.2	7.7	3.5	15	0.3	Opening	11
7.	RADAR, Over-the-Horizon	0.7	0	0.7	21	1.4	0	1.4	21	0.7	Opening	7
8.	RADAR, Medium Range	17.9	14.4	3.5	17	16.9	13.6	3.3	16	0.2	Closing	15
9.	RADAR, Millimeter	9.6	0	9.6	4	18.6	0	18.6	1	9.0	Opening	1
10.	Infrared	12.1	9.4	2.7	19	11.1	8.0	3.1	18	0.4	Opening	9
11.	Television	46.5	34.1	12.4	2	42.8	30.8	12.0	4	0.4	Closing	17
12.	Optical	52.5	47.5	5.0	8	48.4	43.8	4.6	12	0.4	Closing	17
13.	Photography	41.3	26.5	14.8	1	37.1	22.8	14.3	2	0.5	Closing	19
14.	Image Intensification	18.3	11.4	6.9	7	17.0	10.9	6.1	10	0.8	Closing	21
15.	LASER, Blue-Green	7.6	0	7.6	5	8.0	0	8.0	7	0.4	Opening	9
16.	LASER, Other	7.5	0	7.5	6	8.0	0	8.0	7	0.5	Opening	8
17.	Ultraviolet	10.3	7.7	2.6	20	8.0	5.1	2.9	19	0.3	Opening	11
18.	Nuclear	3.7	2.0	1.7	21	2.4	1.0	1.4	21	0.3	Closing	16
19.	Chemical	5.4	0.9	4.5	11	3.0	0.8	2.2	20	2.3	Closing	22
20.	Animal (Birds)	5.0	0	5.0	8	9.8	0	9.8	5	4.8	Opening	2
21.	Acoustic Emission	4.8	0	4.8	10	7.8	0	7.8	9	3.0	Opening	4
22.	Mechanical Vibration	3.6	0	3.6	15	5.7	0	5.7	11	2.1	Opening	5

[a]Cross-relevance totals/10000 (See Appendix M).

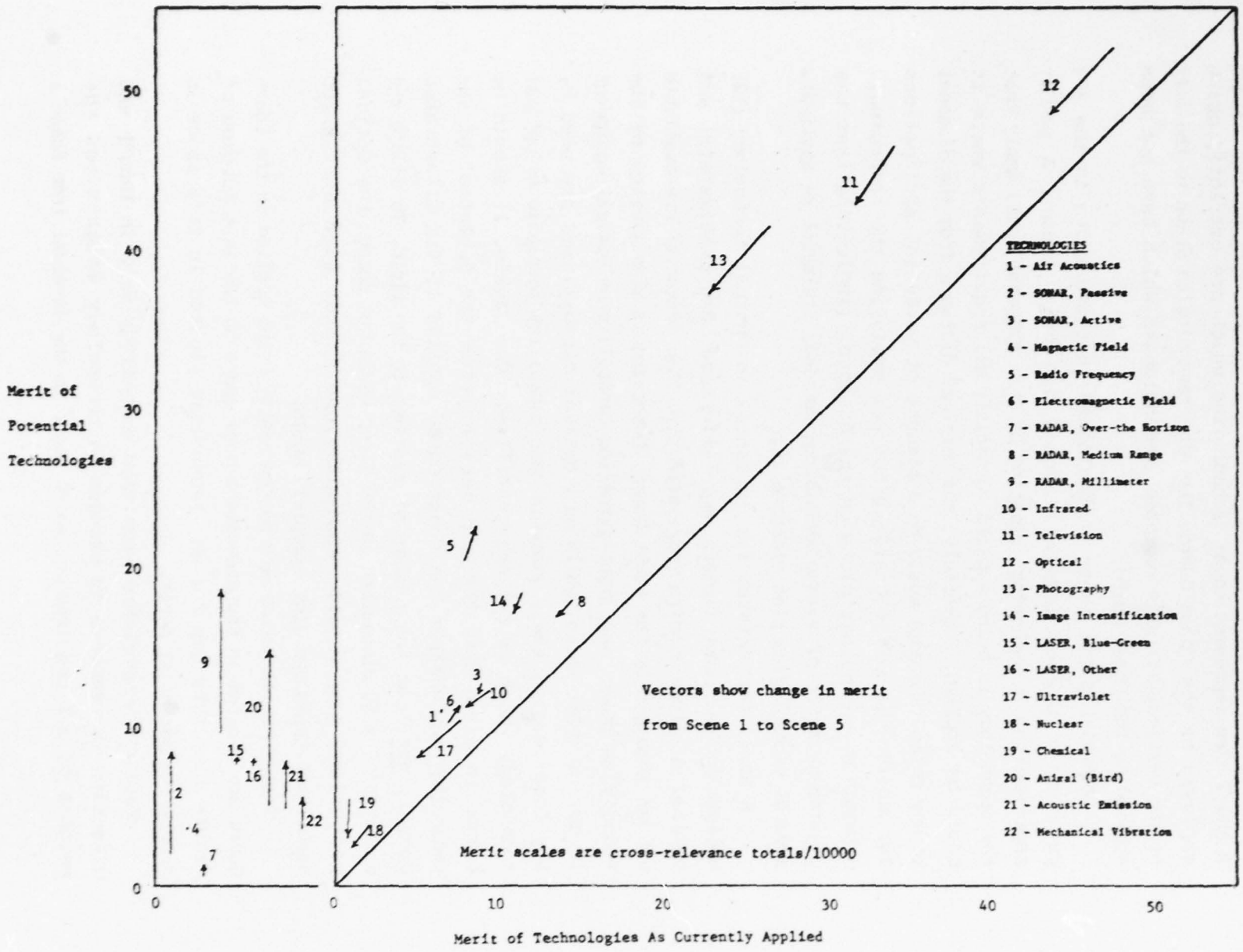


FIGURE 11-1. TECHNOLOGY GAP DIAGRAM

displayed on the two dimensional surface of the figure bounded by the X and Y axes represent those technologies which are currently being employed by the Coast Guard. The nine technologies drawn to the left of the vertical (Y) axis represent technologies which have not been applied by the Coast Guard.

Consider first those technologies that are shown in the X-Y parametric plane. Here a diagonal has been drawn. A point representing a technology plotting on this diagonal would imply that the technology is being applied to satisfy all requirements where it could be applied. Conversely, the vertical distance from the diagonal to any point (the gap) would be a measure of potential applications for which the Coast Guard is not now employing the technology. Although no technology plots on the diagonal (indicating that the potential merit of every technology exceeds its merit as applied), several technologies plot close to it.

A small gap exists, for instance, in Optical technology (12) because optical range finders (more effective than stadimeters) and optical altitude finders (more effective than sextants) are available but not employed by the Coast Guard. Detection is also limited by the magnifying power and light-gathering capability of optical equipment in use. In other words, while many optical capabilities are used by the Coast Guard, there remains some capability intrinsic to optical technology which is not being utilized. Once again, it should be borne in mind that the gap derives from the potential of the technology and whether the Coast Guard applies it (as illustrated above), <u>not</u> from the number of systems in the field. To double the number of 7 x 50 binoculars in the fleet would not change the Optical technology gap at all; equipping one cutter with a 50 x 200 stabilized telescope (for example), would.

Technologies which are not currently being applied in the Coast Guard are plotted in the one-dimensional space on the left portion of Figure 11-1. The gap for any technology plotted in this space is simply its potential merit.

Vectors associated with each technology vary in length and direction in response to changes in technology weights and the weights of all requirements which occur in the interval from Scene 1

to Scene 5. A vector directed toward the upper left (i.e., normal to the diagonal) indicates a gap increase resulting from increases in the relative importance of requirements which the technology could help satisfy, or an increase in the technology weight, or both. Radio Frequency technology (5) is an example. Conversely, a vector, such as Chemical technology (19), directed downward implies a gap decrease. Technologies which plot as very short vectors or points, such as air acoustics (1), imply a relatively constant gap. Technologies which are not currently applied in the Coast Guard are shown on the left portion of the diagram. Vectors associated with these technologies are directed vertically; upward vectors (as for Passive Sonar technology (2)) signify an opening gap.

The significance to the Coast Guard of the information analyzed in this study can be assessed in terms of the technology gaps and gap changes given in Table 11-1 and Figure 11-1. Large gaps generally imply that the associated technologies and systems derived from them could result in high payoffs to the Coast Guard. For instance, the four highest ranked technolgies in Scene 1 are: Photography (13), Television (11), Radio Frequency (5), and Millimeter Radar (9). These technologies also remain in the top four ranks in Scene 5.

Gap changes between Scene 1 and Scene 5 provide further information. Millimeter Radar (9), Animal (Bird) (20), Passive Sonar (2) technologies show the greatest increase in merit; Chemical technology (19), on the other hand, shows a marked decrease in merit. An R&D program focused on large and increasing gaps will generally be appropriate, although gap size and gap change alone provide insufficient information for an R&D commitment.

Technology gap sizes and gap changes can serve as an initial filter for selecting R&D projects. It will also be useful to investigate the technology weights (i.e., maturities) to estimate the technical feasibility and risk involved. See Figure 9-1.

While Table 11-1 and Figure 11-1 provide a gross assessment and comparison of surveillance technologies (since they are predicated on total merit across all requirements), closer consideration of the cross-relevance models in Appendix M can provide insights masked by aggregation. In these matrices, the relative effectiveness (potential

or applied) of any technology in satisfying any requirement may be read by inspection of the cell products (technology weight times requirement weight times cell value); the larger the cell product, the greater the effectiveness. Looking at Potential Technologies in Scene 1 (pages M-2, M-3), for instance, it may be seen (by the high cell values) that Television (11) would be effective in satisfying many requirements but, judging by the cell products, it would be particularly effective in satisfying requirement 037 (Observe: movement of object of interest).

In similar fashion, matrix columns may be inspected to identify technologies which would most effectively satisfy particular requirements. Use of this approach could also help select combinations of technologies to satisfy one or more requirements. The result could be a focused, integrated, and synergistic system of sensors, like the AIREYE system currently under Coast Guard development.

Finally, inspection of the matrices can help identify particular technologies which are needed to satisfy certain requirements even though the overall merit of the technology may not be high. Nuclear technology (18) needed to detect nuclear radiation (SIE 021), is a case in point.

In summary, the Technologies Model is designed to provide a review, screening, and selection mechanism as an initial step in developing a surveillance R&D program. It is designed to facilitate selection of technologies leading to development of integrated, complementary surveillance systems, and to assure that only promising candidate technologies are selected for subsequent technical feasibility and cost-effectiveness studies. The Model provides a basis for the recommendations developed in Chapter 12.

CHAPTER 12 - RECOMMENDED SURVEILLANCE R&D PROGRAM

Development of a plan for research and development requires a highly interactive process with participation of those within an organization who manage the research (Office of R&D), those who perform it (R&D Center and outside contractors), as well as those who require its results (the program managers). As outsiders, the staff of Forecasting International are not qualified to develop any minutely detailed R&D plan for the Coast Guard. It is, however, within our capabilities to sketch or outline a broad skeletal plan. It is and must be the responsibility of the Coast Guard's "R&D community" to complete the fine detail and establish the exact allocation of dollars.

In the sections which follow we will present some concepts of the skeletal plan and discuss certain innovations which we believe will further the transfer and utilization of new and/or high technology to the ultimate benefit of the Coast Guard.

In the preparation of the suggested R&D plan certain assumptions have been made:

1. The level of funding for the surveillance RDT&E budget will amount to approximately $1,000,000 per year.

2. Any effort in this area which the Coast Guard can mount will be very small in comparison to those efforts currently being sponsored by the U.S. Navy, NASA, and other segments of the federal government.

3. An ultimate goal of any R&D effort within the Coast Guard is to ensure maximum return on the invested dollar. Thus a desirable policy is to "buy in at the margin" to benefit from on-going or projected programs.

Underlying these three assumptions is the belief that most technologies which can benefit the Coast Guard in meeting its various surveillance requirements have been or are being investigated (to a depth greater than is possible within the Coast Guard) by the U.S.

Navy, NASA, and other segments of the U.S. Government. In that case, why should the Coast Guard undertake basic research efforts when by carefully monitoring and soliciting information from other sources, the same results can be made available in a timely and useful fashion? In plain language, the Coast Guard should "beg, borrow or steal" the research it needs wherever feasible, except in core areas, i.e., where requirements are unique to the Coast Guard and R&D efforts by agencies outside the Coast Guard are insufficient. A technology transfer mechanism should be established to facilitate acquisition of needed research results in all other areas, including that of surveillance. We recommend that the USCG set up an R&D liaison office within the physical facilities of the Office of Naval Research (ONR) in Arlington, Virginia. This office should be provided with adequate manpower such that all areas of current research within the Navy can be closely monitored and any results which can be applied to the Coast Guard should be considered. Further, any results that become available should be transmitted to the Coast Guard RDT&E community for immediate assessment. The potential benefits of establishing such an office at ONR, to the whole Coast Guard R&D effort, are so broad that we recommend funding at the highest R&D level within the Coast Guard, with specific funding from the surveillance area being maintained at a minimal level, although this segment would certainly profit from the resultant information transfer.

A constraint which becomes immediately apparent in attempting to formulate a R&D plan is that only the broadest program outline can span a period of 25 years. Development of a detailed R&D plan is necessarily an iterative process, requiring continual reassessment. It should cover only a brief period into the future, with re-programming and necessary modification at least once a year. Accordingly, the remainder of this chapter will focus upon a time increment covering the next five years, with heavy emphasis on the first two or three years and less upon the last two.

Our proposed R&D plan consists of two major portions. The first concerns specific recommendations for the establishment of a Technology Transfer Team (T^3) liaison office preferably at the Office

of Naval Research, as well as the initiation of an Interdisciplinary Research and Development Group co-located with the T^3 group at ONR.

Technology Transfer Team. We feel that the benefits of the T^3 group would accrue to the whole Coast Guard, which is why we recommend that it be located at ONR, and that it not be limited to consideraton of surveillance technologies. Such an establishment would require, at a minimum, four to six technical personnel plus technicians and administrative support. Serious attention should be paid to the need for continuity in such a group, whether of military or civilian composition. A gross estimate of the initial funding required would be on the order of $350,000 to $400,000. As mentioned previously, we feel that the T^3 group should have a broad base of financial support, and therefore have excluded these estimates from the funding patterns shown later in this chapter.

Even if the Coast Guard rejects the recommendation to set up an overall T^3 liaison in ONR, FI still recommends that the Coast Guard undertake for surveillance alone the establishment of a T^3 team to be located at ONR so as to be away from the day-to-day "fire drills" that take place in the Office of Research and Development. This Coast Guard T^3 group should have assigned to it at least two technical people as well as a secretary and should have, based upon exploratory contacts with the Navy, not only the ability to review all R&D being supported by ONR, but also access to the Naval Research Laboratory (NRL) for further and indepth contacts. This office would have the ability to monitor the progress of various research projects and technologies which are of immediate and urgent interest to the Coast Guard, both here and abroad. These personnel should have the ability to disseminate information to the Navy concerning Coast Guard needs and to act as a "switching point" for the dissemination of Navy-developed information to the appropriate Coast Guard individuals and facilities.

One of these two technical individuals should have the responsibility for monitoring ONR-supported studies, the work of NRL, DoD ARPA, and all of the ONR reports from overseas, both military and civilian. More specifically, the first individual should be responsible for the basic research going on at NRL and the millimeter

wave radar work going on in Britain, the blue-green laser work going on in NRL, and, of course, any work in these areas supported in the academic institutions by ONR.

The other individual should have the responsibility for monitoring and transferring the technology that is being worked on in the Office of the Chief of Naval Material and in the R&D Planning Office of the Chief of Naval Operations. This R&D falls more nearly into the Systems Area and is performed by the Navy's in-house laboratories as well as its industrial contractors. This second individual should be responsible for material being generated by the private contractors as well as those being tested in the fleet, and the exploratory and advanced development going on at the Coastal Defense Laboratory in Panama City, Florida; the Navy Electronics Center in San Diego, California; the higher powered sonar units being developed by the Underwater Sound Laboratory in New London, Connecticut; the SOSUS and AUTEC work as well as underwater port surveillance at Norfolk, Virginia. He should maintain close liaison with the Director of the CNO's Office of R&D (CNO Op-987) in order to remain cognizant of surveillance R&D work (classified higher than Secret) being conducted by all three Services.

Additionally, if a third technical person could be assigned, he should be charged with transferring space surveillance technology back from NASA to the Coast Guard. He could also be useful in bringing back satellite navigation information that could be of use to the Coast Guard and he could act as a respository for Air Force surveillance and navigation systems information. Finally, one of the T^3 team should come from the Coast Guard R&D Center and should be rotated periodically (annually is recommended). This would enhance technology transfer from team to center for application efficiency.

The estimated cost of this limited T^3 group would be between $150,000 and $200,000 a year. This figure includes salaries, overhead, and a liberal allowance for travel, document reproduction, etc.

Interdisciplinary R&D Team. The second recommendation in this first portion of the proposed program concerns the establishment of an interdisciplinary R&D team. This is extremely important in today's

world, where almost no system operates purely by utilizing one technology. This interdisciplinary group should have the capability of utilizing the rapidly expanding and growing communications and computer arts to act as "glue" between the individual technologies as well as for the manipulation and processing of the data obtained by individual sensors.

We believe that the utilization of a combination of technologies for surveillance in conjunction with the proper mix of communications and data processing can provide orders of magnitude improvement over the next 25 years over the capabilities currently available to the Coast Guard. As the other Services are also discovering, most bottlenecks in the application of advanced technology now lie in the areas of interpretation and/or integration, rather than in the improvement of individual technologies. In addition, most advances are being made at the interface of two technologies. The following disciplines are examples: biochemistry, electromagnetics, biophysics, nuclear chemistry, etc. That is also why we believe this interdisciplinary organization should be co-located with the T^3 liaison group. (cf, Project HINDSIGHT[1]). It should be noted that due to the difficulty of transfering technology and vital information across organizational and spacial barriers special care should be taken to assure that these groups are coupled with Coast Guard Headquarters and the Coast Guard R&D Center.[2]

Consideration of the various contributory technologies leads us to the second major portion of the broad R&D program which we wish to propose. It will be useful to break the Coast Guard RDT&E budget into three categories (Technology Transfer, Advanced Development, and Prototype Test and Evaluation) for the purpose of outlining the allocation of resources. The first of these, Technology Transfer, has been discussed in the first portion of this chapter. An annual allocation of $200 K, or 20% of the $1000 K available, will be assigned to this category.

The apportionment to the remaining categories should not differ greatly from that which other government agencies (especially DOD) and industry have historically found to be effective. Within DOD Advanced Development accounts for approximately 20% of RDT&E

expenditures[3]; industry allocations, in analogous high technology areas, favor T&E somewhat more heavily. On balance, it appears that apportionment to Advanced Development and Prototype T&E in the ratio of approximately 1 to 5 is a reasonable planning figure for the Coast Guard. On this basis, the annual surveillance R&D funding schedule would be as follows:

Category	Percent Allocated	Dollars Allocated
Technology Transfer	20	$200 K
Advanced Development	13	133 K
Prototype T&E	67	667 K

With the foregoing allocation in mind, we turn now to specific applications. Table 12-1 extracts pertinent information from previous chapters of this report. This table lists the seven technologies showing the largest Scene 1 gaps together with their gap changes from Scene 1 to Scene 5 (from Table 11-1) and their Scene 1 states of development (from Figure 9-1).

It is suggested that Advanced Development funds be applied to those technologies which have not yet reached the mature state of development (i.e., maturities B and C in Table 12-1) and which may lead to the satisfaction of Coast Guard unique requirements. Selection of the particular technology or technologies for development should be undertaken after detailed analysis of the probable benefits to be derived. A long-term commitment is required.

It is suggested the prototype T&E funds be allocated approximately equally to all of the technologies listed. Within this framework, detailed investigations should be undertaken to assure the greatest return on the money expended (this would favor the highest ranking technologies). Particular emphasis should be placed on integrating two or more of these technologies (and perhaps others not on the list in Table 12-1) into combined systems to meet particular surveillance requirements. The AIREYE project, for example, is an excellent illustration of what is intended here. Inspection of the Technologies vs. Requirements matrices in Appendix M should suggest candidate combinations of technologies for Prototype T&E.

TABLE 12-1. TECHNOLOGIES RECOMMENDED FOR DEVELOPMENT IN SCENE 1

Technology Number	Description	Scene 1[a] Gap Rank	Gap Change[a] Rank	Gap Change[a] Sense	Scene 1 State of Development[b]
13	Photography	1	19	Closing	D - Mature
11	Television	2	17	Closing	D - Mature
5	Radio Frequency	2	6	Opening	D - Mature
9	Millimeter Radar	4	1	Opening	B - Early Rapid Growth
15	Laser, Blue-Green	5	9	Opening	B - Early Rapid Growth
16	Laser, Other	6	8	Opening	B - Early Rapid Growth
14	Image Intensification	7	21	Closing	C - Late Rapid Growth

[a] From Table 11-1.

[b] From Figure 9-1.

Finally, implementation of the surveillance R&D program outlined in this chapter should be adjusted or phased with ongoing efforts to assure efficiency and economy.

NOTES FOR CHAPTER 12

1. The findings of Project HINDSIGHT, given in Reference 25, are particularly pertinent here.

2. Reference 21 provides an extremely valuable discussion of technology transfer in a situation which is very much analogous to the Coast Guard's. The concept of barriers and bonds is right to the point.

3. The estimates are complicated by the different definitions of terms used within the R&D community. Volume 1 of Reference 25 is pertinent. The percentages cited are also drawn from a conversation between Dr. Edward M. Glass (Office of Deputy Director of Technology, DOD) and Dr. Marvin J. Cetron on October 22, 1965. That this apportionment continues to obtain is supported by the following table:

DISTRIBUTION OF DoD RDT&E

(Current $ x 10^6)

Year	Total RDT&E Obligations	Technology Base -1	Advanced Technology Development -2	1 + 2	Percentage of Total
1972	7,945[a]	1,462[a]	238[a]	1,700	21.4
1973	8,000[a]	1,376[a]	160[a]	1,536	19.2
1974	8,008[a]	1,353[a]	200[a]	1,553	19.4
1975	8,372[a]	1,372[a]	300[a]	1,672	19.5
1976	9,212[a]	1,487[a]	557[a]	2,044	22.2
1977	10,522[a]	1,682[a]	537[a]	2,219	21.1
1978	11,330[a]	1,805[a]	492[a]	2,297	20.3
1979	12,343[a]	1,990[a]	591[a]	2,581	20.9
1980	13,369[b]	2,280[b]	652[b]	2,932	21.9

[a] An Analysis of Federal R&D Funding by Function: Fiscal Year 1969-79, Division of Science Resources Studies, National Science Foundation, p. 2.

[b] Special Analyses, Budget of the United States Government, Fiscal Year 1980 (Washington, D.C.: Office of Management and Budget) p. 306.

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