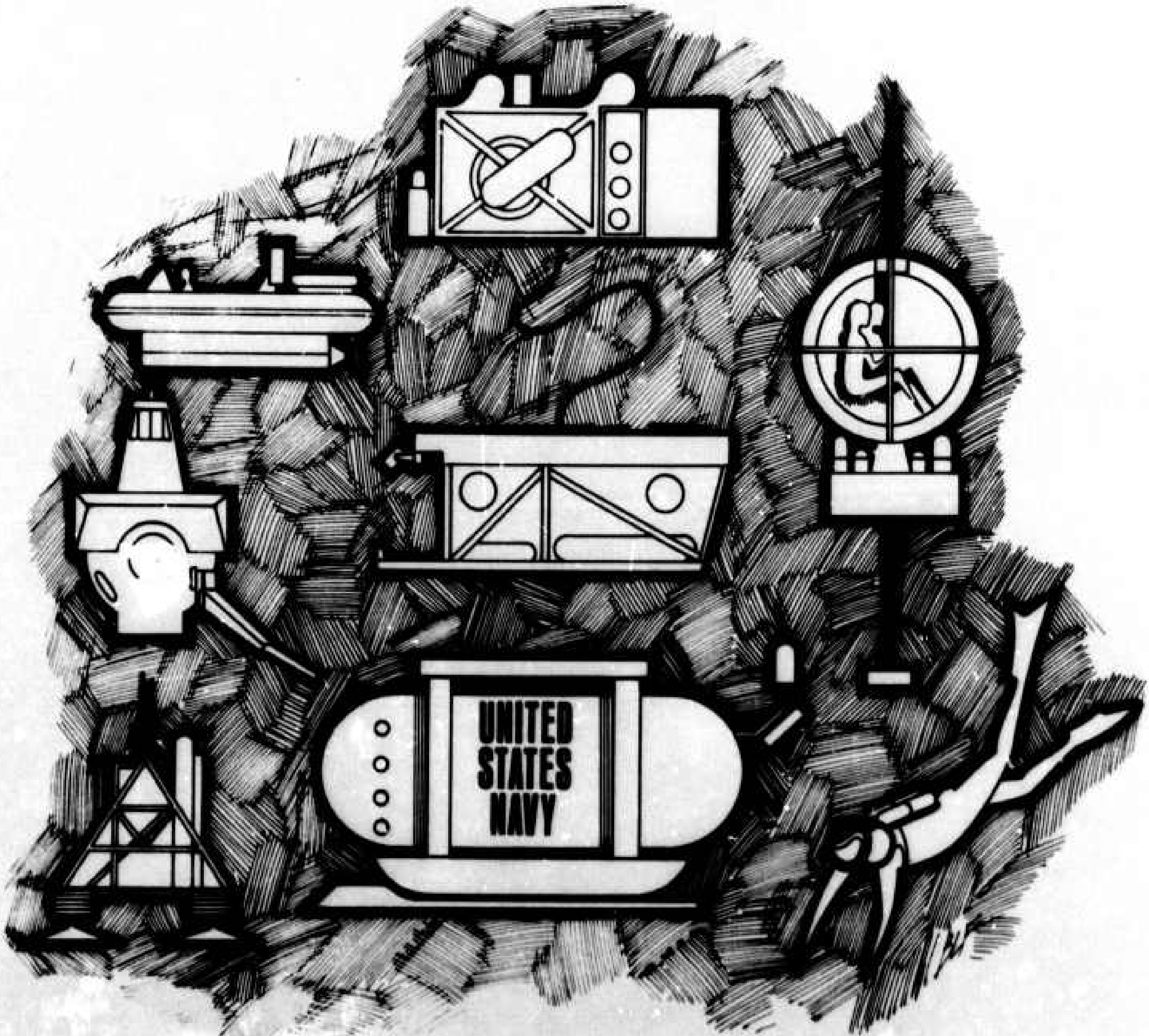
UNCLASSIFIED

AD NUMBER
AD907528
LIMITATION CHANGES
TO: **Approved for public release; distribution is unlimited.**
FROM: **Distribution authorized to U.S. Gov't. agencies only; Proprietary Information; OCT 1972. Other requests shall be referred to Naval Material Command, AttN: MAT 0341, Washington, DC 20360.**
AUTHORITY
CNM D/N ltr, 14 Aug 1973

THIS PAGE IS UNCLASSIFIED

DEEP OCEAN TECHNOLOGY PROJECT
DEVELOPMENT OBJECTIVES ASSESSMENT



DISTRIBUTION LIMITED TO U.S. GOVERNMENT AGENCIES ONLY;
PROPRIETARY INFORMATION; OCTOBER 1972. OTHER REQUESTS
FOR THIS DOCUMENT MUST BE REFERRED TO HEADQUARTERS NAVAL
MATERIAL COMMAND (MAT [redacted]) WASHINGTON, D.C. 20360
0341

OCTOBER 27, 1972 **VOLUME 1**

DEEP OCEAN TECHNOLOGY PROJECT

DEVELOPMENT OBJECTIVES ASSESSMENT

VOLUME 1

An assessment of specific technological events, anticipated and/or desired in the near future, required to advance the state-of-the art in ocean engineering for the achievement of Naval objectives.

This study was conducted in support of the Deep Ocean Technology (DOT) Project 43-36X.

October 27, 1972

PREFACE

The U.S. Navy is very grateful to each of the individuals and organizations who participated in the three cycles of the Deep Ocean Technology Development Objectives Assessment. Their enthusiastic contributions have added immensely to the knowledge and results contained in this study. Their generously offered time and experience are sincerely appreciated.

TABLE OF CONTENTS

I. INTRODUCTION

The Deep Ocean Technology (DOT) Project has as general requirements the definition, analysis, and development of the technological state-of-the art for ocean engineering in the deep ocean environment. The specific requirements for the DOT Project are that there be adequate demonstrated technology options available to support the specific operational requirements for deep ocean programs which are generated in the foreseeable future. Such options are those specific technology developments required to achieve operational systems that will fulfill the Navy's future requirements in manned and unmanned submersible work systems, seafloor construction systems, and weapons support systems. Within these bounds the question naturally arises--what options are the most suitable and how should their development be undertaken? After four years of development effort in implementation of the original project objectives, and in view of past and current funding limitations, it appeared necessary to reassess the DOT Project development programs to ensure that the most cost-effective approaches were being taken. Another hard look at technology state-of-the-art and the cost and time requirements to advance the state-of-the-art was therefore required.

In assessing the technology base in ocean engineering, it was considered desirable to invite the wider participation of the ocean community in determining the optimum course of action in advancing the present state-of-the art necessary to meet the Navy's needs. Advancements and developments in ocean engineering have and are currently taking place outside the Naval realm. Participants in these outside programs, by virtue of professional interest or otherwise, have an interest in the future developments and requirements in ocean engineering, and the contribution of their current expertise in their technical fields to the development planning required to fulfill the objectives of the DOT Project has been of great value. Due to the nature of the

the DOT Project, the information sought was relatively specific and related to technical or discipline areas, thereby allowing experts to readily contribute without appreciable background briefing. The method selected to obtain this expert advice was a modified DELPHI technique (see Section II).

The objective of the DOT Development Objectives Assessment was to evaluate specific technological events, anticipated and/or desired in the near future, required to advance the state-of-the-art in ocean engineering to achieve Naval objectives.

II. THE SELECTED ASSESSMENT PROCEDURE

DELPHI is the name given to a technique for soliciting and assessing the opinions of a group of people who are especially knowledgeable in specific areas under consideration. The DELPHI procedure has three distinctive characteristics: Anonymity, controlled feedback, and statistical group response.

To maintain anonymity throughout the study, the experts were solicited by means of a coded questionnaire, and at no time was any response referred to by an individual's name or organization. The device of anonymity was used to reduce the effect of a socially dominant or prestigious individual, the bandwagon effect of majority opinion, and the psychological factors of deceptive persuasion commonly apparent in committee or round table discussions.

Controlled feedback was conducted in this study by means of a consensus summary between each of the three cycles, whereby the collected data from the previous cycle were statistically reduced and fed back to the participants along with their original estimates and a new, blank questionnaire which they were to complete in light of what was said by the other experts. The device of controlled feedback, by the use of consensus summary sheets, allows each participant to reappraise his response such that a convergence or consensus may be allowed. Also, those who diverge appreciably from the consensus (outliers) can be detected for future inquiry as to the reasons for their nonconforming estimates.

The statistical group response was conducted by objectively derived, predetermined procedures. The summaries or conclusions determined in any phase of this study were derived by formal statistical methods (i.e., without judgement) to ensure statistically valid and unbiased conclusions.

The selected procedure for the Deep Ocean Technology (DOT) Project Assessment was in accordance with the following steps:

Step 1. Desired and/or anticipated technological events that are candidates in fulfilling future deep ocean engineering operational requirements of the Navy were generated. These events contained specific hardware performance specifications for systems components. They were specific in the sense that they apply to fundamental components of basic systems or techniques appropriate to advancing the Navy's ocean engineering technology requirements. Of the 286 events generated, 266 were selected for the first cycle. At its conclusion 6 events were added, at the suggestion of the participants, and this total, 272, was maintained throughout the remaining iterations of the study. The 272 events were divided into 9 technology areas and 30 sub-technology areas, as shown in Figure 1.

Step 2. One team of experts was selected for each of the nine technology areas. Each team was composed of members from Naval activities, from other government activities, and from the private and academic sectors. The distribution of team members at the conclusion of the assessment is shown in Figure 2.

Each team of experts was selected from authors of published papers, members of professional societies, recommendations of the National Academy of Engineering-Marine Board, and from the recommendations of program managers within the Navy and other federal agencies. Selection criteria required that each member (a) be currently employed in an endeavor related to at least one of the nine technology areas, (b) have a technical orientation, and (c) where possible, have some project management experience in research and development.

Step 3. The members of each team were asked to evaluate anonymously, by means of a mailed questionnaire, the projected technology events in accordance with the following criteria:

Technology		Sub-Technology	
I.	Materials and Structure	A.	Massive Glass
		B.	Fiber Reinforced Plastics
		C.	Concrete
		D.	Metals
		E.	Buoyancy Materials
		F.	Miscellaneous
		G.	Structures
II.	Machinery and Equipment	A.	Remote Unmanned Work Systems
		B.	Ballast Systems
		C.	Hydraulic Systems
III.	Seafloor Construction	A.	Construction by Divers
		B.	Site Selection and Preparation
		C.	On-Bottom Construction
		D.	In-Bottom Construction
IV.	Power Sources, Conversion and Transmission	A.	Power Sources
		B.	Electrical Transmission and Conditioning Equi ment for Deep Submergence Vehicles
		C.	Transmission and Conditioning Equipment for Deep Ocean Fixed Installations
V.	Propulsion	A.	Propulsors
		B.	Power Transmission
		C.	Integral Energy & Power Sources
		D.	Propulsion Motors
VI.	Surveillance and Communications	A.	Bottom Positioning
		B.	Surveillance and Viewing
		C.	Communications
VII.	Instrumentation and Display	A.	Life Support Monitoring
		B.	Submersible Positioning and Guidance Instrumentation
		C.	Site Selection Instruments
VIII.	Load Handling and Transportation	A.	Near - Bottom Transport & Positioning
		B.	Guidance
		C.	Lifting and Lowering
IX.	Life Support and Related Systems	A.	Life Support and Related Systems

Figure 1. TECHNOLOGY AND SUBTECHNOLOGY BREAKDOWN

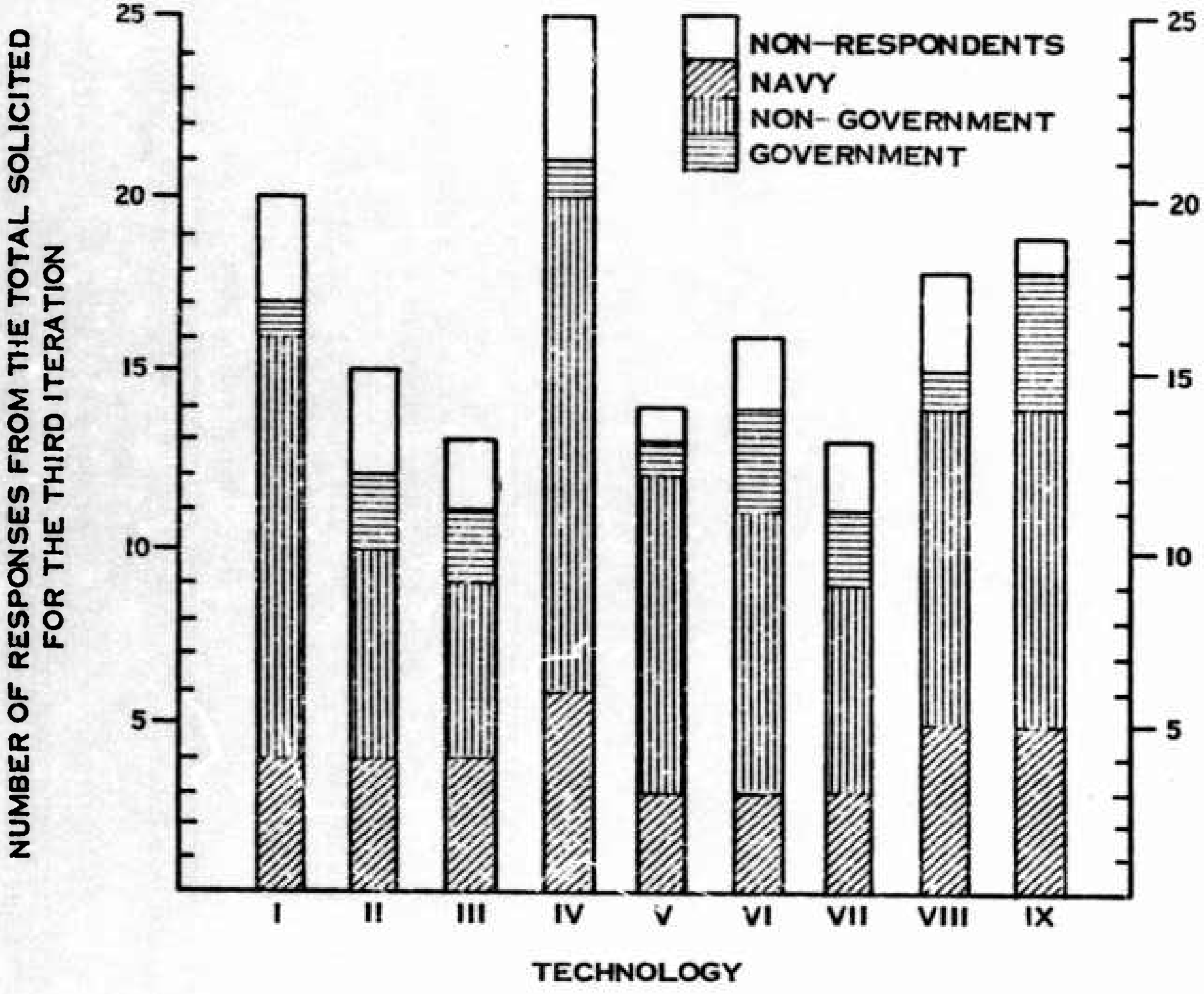


Figure 2. DISTRIBUTION OF TEAM MEMBERS

a. System Criticality: How critical is the development of the system or equipment in achieving a given objective?

b. Degree of Risk: What degree of risk is involved in achieving a successfully demonstrated prototype/capability based upon anticipated and unanticipated unknowns.

c. Desired Course of Action: Disregarding degree of risk, should the development of the event be a short-range, medium-range, long-range, or an undesirable goal?

d. Probable Timing: What is the earliest, most likely, and latest year in which a prototype will be successfully demonstrated in the environment?

e. Estimated Costs to Achieve: How much will it cost to develop a prototype capable of operating in the required environment?

The above evaluation criteria are discussed more fully in the following section. Figure 3 illustrates the convenient format of the questionnaire.

Step 4. After the initial round, two additional cycles were made over a period of four months each, allowing each expert to reconsider his previous responses relative to those of the other team members in order to allow, where possible, a consensus of opinion.

The consensus sheet for each iteration was returned to each participant for his own use in accordance with the format shown in Figure 4. The participants were asked to reconsider their previous estimates according to the following procedures:

VIC Sub-Technology: Communications **Objective:** To advance the technologies necessary for real-time, reliable, quality voice and data communications links between the various surface and bottom facilities and vehicles in the environment required.	SYSTEM CRITICALITY			DEGREE OF RISK				PROBABLE TIMING			DESIRED COURSE OF ACTION				ESTIMATED COST TO ACHIEVE		
	ESSENTIAL	DESIRABLE	UNNECESSARY	.1 (PROTOTYPE)	.4 (EXPERIMENTAL MODEL)	.7 (STUDY OR SIMULATION)	.9 (UNPROVEN)	EARLIEST (YEAR)	MOST LIKELY (YEAR)	NOT LATER THAN (YEAR)	SHORT RANGE GOAL	MEDIUM RANGE GOAL	LONG RANGE GOAL	UNDESIRABLE GOAL	LOWER LIMIT ($)	UPPER LIMIT ($)	
Events:																	
VIC01 An underwater acoustic, multi-channel (voice and digital data), high data rate communication link capable of secure communications between submersibles, bottom habitats, and the surface at 20-mile distances and down to 20,000-ft ocean depths with negligible multi-path and reverberation interference.	✓					✓		76	80	85			✓		10 M	30 M	
VIC02 An underwater laser multi-channel, high data rate, communication link between submersibles, habitats, and the surface with a range of 1,000 ft in seawater with a light attenuation coefficient of 0.12/meter.			✓				✓	78	82	86				✓	30 M	50 M	
VIC03 An underwater portable acoustic, two-way voice communications link for communications between divers, habitats, vehicles and the surface, capable of functioning reliably down to 1,000 ft depths and over a range of 1 mile.																	
VIC04 A helium-speech unscrambler for two-way voice communications between divers, habitats, vehicles, and the surface, capable of functioning reliably down to 1,000- ft depths.																	
VIC05 A tactical (physical stimulus of different body areas) two-way communications system for use as a means of communications.																	
VIC06 A wireless split transformer link through a pressure hull of appropriate material, without penetration, capable of transmitting two-way multi-channel digital communication signals at ocean depths down to 20,000 ft.																	

Page 5 of 6

Figure 3. EXAMPLE FORMAT OF QUESTIONNAIRE

EVENTS	SYSTEM CRITICALITY			DEGREE OF RISK				PROBABLE TIMING			DESIRED COURSE OF ACTION				ESTIMATED COST TO ACHIEVE	
	ESSENTIAL	DESIRABLE	UNNECESSARY	.1 (PROTOTYPE)	.4 (EXPERIMENTAL MODEL)	.7(STUDY OR SIMULATION)	0 (UNPROVEN)	EARLIEST (YEAR)	MOST LIKELY (YEAR)	NOT LATER THAN (YEAR)	SHORT RANGE GOAL	MEDIUM RANGE GOAL	LONG RANGE GOAL	UNDESIRABLE GOAL	LOWER LIMIT ($) MILLIONS	UPPER LIMIT ($) MILLIONS
VIB15	33%	59%	9%	9%	27%	55%	9%	72 $\bar{x}$=77 90 74 76	73 $\bar{x}$=80 00 78 80	73 $\bar{x}$=84 10 80	18%	46%	27%	9%	1 $\bar{x}$=[illegible] 00 4	2 $\bar{x}$=[illegible] 1[illegible] 16
VIC01	57%	43%	0%	7%	14%	29%	50%	73 $\bar{x}$=77 90 75	74 $\bar{x}$=81 00 80 85	75 $\bar{x}$=84.5 10 80	27%	20%	40%	13%	.5 $\bar{x}$=26 20[illegible] 5	1.5 $\bar{x}$=21.3 [illegible] 5 20
VIC02	9%	45.5%	45.5%	0%	0%	33%	67%	74 $\bar{x}$=76 80 76	77 $\bar{x}$=80 85 78	79 $\bar{x}$=82.5 90 79	10%	10%	30%	50%	.1 $\bar{x}$=3 5	5 $\bar{x}$=9.7 [illegible]
VIC03	64%	36%	0%	14%	65%	14%	7%	72 $\bar{x}$=74 75 74	73 $\bar{x}$=75 80 74 75	74 $\bar{x}$=77 85 76	62%	38%	0%	0%	.04 $\bar{x}$=[illegible] 5	.0[illegible] $\bar{x}$=[illegible] 1[illegible]
VIC04	64%	29%	7%	36%	28%	36%	0%	72 $\bar{x}$=74 76 73	73 $\bar{x}$=75.5 80 74	74 $\bar{x}$=77 85 75	69%	23%	0%	8%	.1 $\bar{x}$=[illegible] 2 .5	.15 $\bar{x}$=[illegible] 4 1
VIC05	0%	38%	62%	0%	10%	20%	70%	73 $\bar{x}$=76.5 80 75 78	76 $\bar{x}$=80 85 80	77 $\bar{x}$=87 00 80 00	0%	10%	30%	60%	.2 $\bar{x}$=3 10 .5 10	.6 $\bar{x}$=[illegible] 1 [illegible]
VIC06	13%	74%	13%	7%	36%	36%	21%	72 $\bar{x}$=74.5 80 75	72 $\bar{x}$=80 90 74	72 $\bar{x}$=82 00 80	54%	8%	23%	15%	.0[illegible] $\bar{x}$=2 5 .5 1	.15 $\bar{x}$=7.[illegible] [illegible]
VIC07	0%	54.5%	45.5%	0%	0%	20%	80%	72 $\bar{x}$=78 90 76	74 $\bar{x}$=83 00 78 85	76 $\bar{x}$=90 10 00	10%	10%	40%	40%	.2 $\bar{x}$=4.5 10 1	.4 $\bar{x}$=17.2 [illegible]0 5

Page 3 of 4

Figure 4. TYPICAL CONSENSUS SHEET

a. Read the"sub-technology objective" in the upper left corner of the new questionnaire, and then read each of the events.

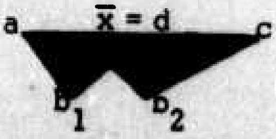
b. Review your previous estimates in the old questionnaire.

c. Note the cumulative responses in the consensus sheet.

d. Mark the new questionnaire with your reconsidered opinion, whether changed or unchanged. It is important that all entries be made on the new questionnaire.

Under the headings "System Criticality," "Degree of Risk," and "Desired Course of Action" the participants were given the percentages of responses in each column. Unanswered events were considered as non-responses and not included in the percentages. Therefore the sum of percentages of all columns under each heading equals 100%.

Under the headings "Probable Timing" and "Estimated Cost to Achieve" the participants were given distribution triangles. Shown on the triangle were the two extremes, the mean, and the mode or modes. The two extremes represented the earliest year or lowest cost and the latest year or highest cost expressed under each separate column; the mean represented the average, and the mode(s) represented the most frequent estimate(s) in each column. In some cases, there were no modes (see Figure 5.)



a and c are the two extremes; b_1 and b_2 are the modes; d is the mean. (Note: This example is bimodal.)

Figure 5. DISTRIBUTION DIAGRAM

III. EXPLANATION OF STATISTICAL ANALYSIS METHOD AND RESULT SHEET DATA ITEMS AND ENTRIES

METHOD OF ANALYSIS

This section delineates the formalized statistical methods used to reduce the data collected from the Objectives Assessment. Opinions and estimates were offered for five basic criteria for each event. Figure 6 is a sample of the line graphs and charts used to illustrate the final assessments. The five criteria were evaluated in the following ways:

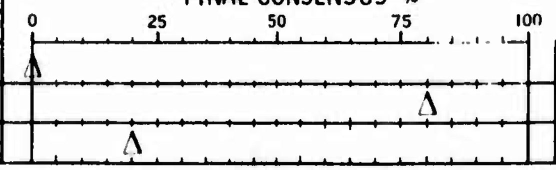
1. System Criticality

The experts were asked to estimate how critical the development of an event is in achieving a given subtechnology objective. They were asked to select one of three opinions: (a) essential, (b) desirable, and (c) unnecessary. The data in the results sheet under this heading are the calculated percentages of the responses to these choices. Unanswered events were considered as non-responses and are not included in the percentages. Therefore the sum of the percentages of each event equals 100%. The percentage gain or loss from the second round is given to show the trend of consensus at the conclusion of the assessment; it represents the difference between the percentage of response of the second round and percentage of response of the third round of each of the three individual choices. Thus, it can be determined whether a system was gaining or losing in any one of the three criticality opinions at the conclusion of the assessment. The conclusion as to system criticality for each event was determined by the highest percentage given to one of

DOT ASSESSMENT RESULTS

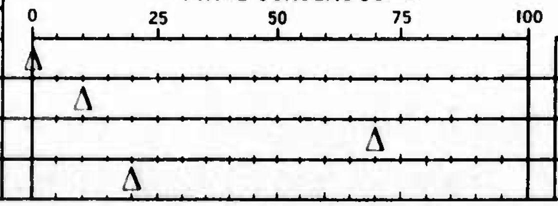
EVENT: IIIC08 A raft-type foundation for large, heavy structures (100 ft x 100 ft) with a differential settlement of less than 3 inches under uniform load of 5 lbs per square foot. The sediment is ooze 50 ft deep at water depth of 8,000 ft.

SYSTEM CRITICALITY



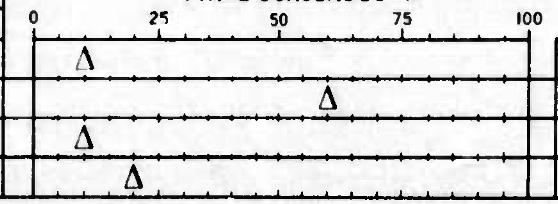
N= 10	PERCENTAGE		FINAL CONSENSUS %	CONCLUSION
	LOSS	GAIN		
ESSENTIAL	9		0 %	
DESIRABLE		7	80 %	DESIRABLE
UNNECESSARY		2	20 %	

DEGREE OF RISK



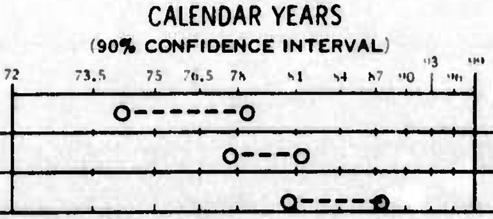
N= 10	PERCENTAGE		FINAL CONSENSUS %	CONCLUSION
	LOSS	GAIN		
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL		1	10 %	
.7 SIMULATION	3		70 %	.7
.9 UNPROVEN		2	20 %	

DESIRED COURSE OF ACTION



N= 10	PERCENTAGE		FINAL CONSENSUS %	CONCLUSION
	LOSS	GAIN		
SHORT RANGE GOAL			10 %	
MEDIUM	10		60 %	MEDIUM
LONG			10 %	
UNDESIRABLE		10	20 %	

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
8	EARLIEST	3.4	75	76.3	2 - 6½ YRS
8	MOST LIKELY	4.1	80	80.1	5½ - 11 YRS
8	NOT LATER THAN	4.8	85	84.3	9 - 15½ YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
7	LOWER LIMIT	1.1	1 M	1.29 M	.46 - 2.12
7	UPPER LIMIT	2.7	2 M	4.07 M	2.07 - 6.08

Figure 6. EXAMPLE ASSESSMENT RESULTS

the three choices. In the case of ties, the conclusion was determined by selecting the criticality choices that had gained rather than lost percentage points from the second round. If an event resulted in a criticality that was equal in percentage and percent gain or loss, the selected conclusion was then determined to be both choices.

2. Degree of Risk

The experts were asked to estimate how much risk (chance of failure) would be involved if a development effort were undertaken today to achieve a successfully demonstrated prototype of the equipment or system described by the event. Estimates of risk were to be based on the current state-of-the-art. The experts were asked to choose one of the four given risks listed as follows:

a. .1 - System or equipment has been demonstrated in the operational environment as a prototype.

b. .2 - System or equipment has been demonstrated in an operational or simulated environment as an experimental model.

c. .7 - System or equipment currently has been demonstrated in a competent study or simulation.

d. .9 - System or equipment currently has not been established as feasible.

The data displayed in the result sheet were derived by the methods used for System Criticality.

3. Desired Course of Action

The experts were asked to give an opinion as to what course of action should be assigned to the system or equipment described in the event. They were asked to choose one of the four categories of desired course of action listed as follows:

a. Short-Range Goal - Development effort should be undertaken immediately and completed in the near future.

b. Medium-Range Goal - Development effort should commence in the near future.

c. Long-Range Goal - Development effort should be scheduled for the distant future.

d. Undesirable Goal - Development effort should not be undertaken.

The data displayed in the result sheet were derived by the methods used for System Criticality and Degree of Risk.

4. Probable Timing

The experts were asked to make three predictions as to the time the event would probably take place. They are as follows:

a. Earliest Year - The earliest calendar year in which the event could be accomplished, given high priority and full resources.

b. Most Likely Year - The most likely calendar year of accomplishment, considering probable or moderate assignment of priority and resources.

d. Not Later Than Year - The calendar year in which the event is reasonably certain to have been accomplished.

A distribution of dates was collected for each category and since the probability is the same that all the experts would give an estimate differing from the true expected value by the same amount, it is then justifiable to assume that the nature of this distribution is normal. Therefore, the Student's "t" test was best suited as an analytical method to determine a confidence interval for each of the respective categories. The noted statistician Bartlett and others have shown that the "t" test gives quite good results even for considerable departures from normality.[1] Bartlett says, "Unless the data are very extensive, it is seldom possible to demonstrate that they are not normal. The standard errors of skewness and kartosis are so large with samples of moderate size that only very marked non-normality could be detected."[2] The "t" test has been shown from past experience to be valuable for sample sizes less than 30, which occurred in every event of the assessment. In any case the selection process here employed indicated a normally distributed phenomenon.

A confidence interval of 90% was determined to be the optimum interval since the intervals at 95% and 99% were too large to be meaningful and a confidence interval of 85% or less was less credible than desired.

The data represented in the results sheet under the heading, Development Time, show a 90% confidence interval of the estimated years, rounded to the nearest half-year, and derived from the following formula:

$$\bar{x} - t_{\alpha}\frac{\sigma}{\sqrt{N}} < \mu < \bar{x} + t_{\alpha}\frac{\sigma}{\sqrt{N}}$$

Lower Limit Upper Limit

---

(1) Bartlett, M.S., "The Effect of Non-Normality on the t-Distribution," Proc. Camb. Phil. Soc., 31, 1935, pp. 223-31.

(2) Bartlett, M.S., "The Use of Transformations," Biometric, 3, 1947, pp. 39-52.

where

$\bar{x}$ = the mean of the sample

t_{α} = Student's t statistic calculated at a probability of $\alpha = .05$

σ = the standard deviation

N = the number of observations

μ = the true or expected value of the mean

Also, the development time interval is given in year quantities from 1972 as well as chronological calendar years.

Additional data includes:

- the <u>mean</u> ($\bar{x}$), calculated according to the following formula:

  $$\bar{x} = \sum_{i=1}^{N} \frac{X_i}{N} ,$$

  and indicates the simple average of the sample data. The mean, thus defined, is affected by extreme values.
- the <u>mode</u> or modes which is the most frequent response or responses. (Note: In cases where there were three or more modes, the median of the modes was selected as this data item entry)
- the <u>standard deviation</u> (σ) calculated according to the following formula:

  $$\sigma = \sqrt{\frac{\sum_{i=1}^{N} X_i^2 - N\left(\sum_{i=1}^{N} \frac{X_i}{N}\right)^2}{N}}$$

  and indicates the central tendency of the distribution. (i.e. it measures the tendency the data have either to spread out (deviate) from the mean or to cluster about the mean.) The standard deviation is also affected by extreme values.

The standard deviation can serve as a convenient descriptor of the distribution of the estimates given by the experts by use of the following general rule of thumb: Plus or minus three standard deviations ($\pm 3\sigma$) from the mean will include 99.73% of the estimates given by the participants and plus or minus one standard deviation ($\pm 1\sigma$) will include 68.27% of the given estimates.

- the number of responses (N).

The Calendar Year development time interval, computed at 90% confidence is shown on the logarithmic scale, ranging from 1972 to 1999 and has the same interval width as that of Development Time.

5. Estimated Cost to Achieve

The experts were asked to estimate two costs (lower limit and upper limit). The costs include labor and materials required to achieve a successfully demonstrated prototype of the equipment or system described. A 90% confidence interval was calculated from the data in accordance with the method used for Probable Timing. All intervals are given in millions of dollars. Additional data includes, as above, the mean, the mode or modes, the standard deviation (σ), and the number of responses N.

RESULTS SHEET DATA ITEMS AND ENTRIES

The following paragraphs explain each of the data items and entries as they appear in Figure 6. At the top of every result sheet is the technology event as it appeared throughout the three cycles of the assessment.

The first three evaluation criteria listed in the left-hand column were analyzed by similar methods and therefore appear on the result sheet in the same form. Immediately to the left of the "Conclusion" column is the calculated percentage that each entry received from the resulting data of the third cycle.

"Final Consensus %," a horizontal line graph with triangular markers, indicates the percentages in each category. These line graphs are included to give a visual representation of the calculated percentages of ease of relative comparison.

The "Percentage Loss/Gain" column indicates the percentage gained or lost from the second cycle in each data category for the event. In cases where there was no percentage gain or loss the column is left blank.

The "N=" listed immediately under the category heading is the number of responses to each of the event criteria.

In the category "Probable Timing," the "Development Time" is based on 1972 and calculated at a 90% confidence interval of the estimated years given by experts. These figures are rounded to the nearest half year. Under the heading "Calendar Years" a 90% confidence interval of the calendar years is displayed on a logarithmic scale ranging from 1972 to 1999. The remaining columns show the mean of the estimates of the experts; the mode or the year most frequently estimated by the participants (in cases where there were three or more modes, the median of the modes was selected at this data item entry); and the standard deviation (σ) calculated from the distribution of estimates given by the experts.

In the category "Estimated Costs to Achieve," the "Development Cost" (in millions) is calculated at a 90% confidence interval of the estimated costs given by the experts. The remaining columns show the mean, the mode, and the standard deviation (σ), computed as in "Probable Timing."

In order to facilitate executive review of this document, a masking technique has been applied to the supporting data of the DOT Assessment Results sheet in order to emphasize the conclusions. This technique is used to stress the pertinent data that will allow rapid review by management personnel.

IV. ORGANIZATION OF THE TECHNOLOGIES, SUB-TECHNOLOGIES, AND EVENTS

This section delineates the organization of the technologies, sub-technologies, and events and discusses both general and specific parameters.

GENERAL PARAMETERS

1. Operational Depths
   - a. Diver depths - 1,000 ft
   - b. Continental margin depths 6,000 to 8,000 feet
   - c. Deep ocean depths down to 20,000 feet
2. Reliability Specifications

a. Man-Rated Systems - A 99.9% reliability at a 90% lower level of confidence (e.g., no more than one failure in each lot of 1,000 for 90 out of 100 lots tested).

b. Non-Man-Rated Systems - A 95% reliability at a 90% lower level of confidence (e.g., no more than five failures in each lot of 100 for 90 out of 100 lots tested).

c. Critical Man-Rated Systems - A 99.9% reliability at a 95% lower level of confidence (e.g., no more than one failure in each lot of 1,000 for 95 out of 100 lots tested).

d. Critical Non-Man-Rated System - A 95% reliability at a 95% lower level of confidence (e.g., no more than five failures in each lot of 100 for 95 out of 100 lots tested).

The above specifications are based on two operational modes: operations involving permanently emplanted or fixed systems and operations involving mobile deployable and recoverable systems. In the case of fixed systems a life expectancy of 10 years is applied. In the case of the mobile system a cyclic requirement of at least 2,000 cycles is applied.

SPECIFIC PARAMETERS

Specific parameters applied to the respective technology areas are explained in the following paragraphs.

I. Materials and Structures

The materials involved in this technology are massive glass, fiber reinforced plastics, concrete, metals, buoyancy materials, and other miscellaneous materials. The operational mode for these materials, except for concrete, is cyclic to depths of 20,000 feet and for at least 2,000 cycles. The objective of concrete is to achieve a fixed operational capability at a given depth for a period of at least 10 years.

II. Machinery and Equipment

In this technology the components selected are those currently believed to impose limitations and therefore require advancement in the state-of-the-art in order to achieve the stated objectives. The selected components are candidates for undersea systems such as manned, untethered, deep submersible, or remote controlled unmanned systems. The general specifications previously stated are applied in this area.

III. Seafloor Construction

The types of undersea construction operations considered in this technology area are site selection and preparation, construction by divers, on-bottom construction, and in-bottom construction. The parameters of construction by divers are limited by the current or projected operational capabilities of a Naval diver. The other types of construction do not involve the use of divers and are therefore directed toward those advancements required to carry out construction operations beyond diver depths.

IV. Power Sources, Conversion and Transmission

In this technology two basic modes of operation are considered: fixed bottom installations and cyclic submersible operations. The power sources considered are thermo chemical, electro-chemical, fuel cell, and storage battery systems; neither nuclear or isotope power sources are considered because of regulations of the Atomic Energy Commission (AEC). High power transmission and communications cabling are considered only for fixed bottom installations and deep submergence tethered (cable controlled) vehicles. Integral power sources for mobile free-swimming vehicles are included in technology V, "Propulsion." Conditioning equipment includes connectors, fuses, circuit breakers, through-hull penetrators, junction boxes, alternators, controllers, and inverters for either fixed or cyclic operations.

V. Propulsion

This technology explores the developments necessary to evaluate and design improved propulsors and propulsor systems, transmissions functioning between motor and propulsor, and propulsion motors for untethered vehicles intended for deep submergence operations, and to provide optimum energy/power sources. Nuclear and isotope energy sources are again not considered because of AEC regulations.

The propulsors desired are those that are highly efficient, reliable, and maintainable; that can provide precise maneuverability, free from entanglement and with minimum bottom disturbance; and that can provide six degrees of motion to the vehicle.

The transmissions must provide improved control and performance, as well as step-up or step-down rpm.

The propulsion motors considered are external to the pressure hull and include AC/DC motors, non-water flooded, or seawater flooded. One-atmosphere motors (i.e., within pressure hull or hard-can) are included in those technologies requiring advancements in the state-of-the-art in such components as shaft seals and hull penetrators.

Integral energy sources are for untethered vehicles and are advancements directed toward increasing power density, energy density, reliability, maintainability, automation, with negligible noise and vibration.

VI. Surveillance and Communications

This technology examines the capability to resolve, observe, locate, and track static and moving objects from and below the surface and to communicate real time information between various surface platforms, subsurface vehicles, fixed bottom installations down to 20,000 feet, and divers' communication down to 1,000 feet. Surveillance systems include active and passive methods of observation such as underwater TV, sonar, hydrophones, high sensitivity gradiometer/magnetometers, and suspended sensor arrays. The communication systems shall be real-time, reliable, and high-quality voice and data transmission between the various surface platforms, submersible vehicles, fixed bottom installations, and divers.

VII. Instrumentation and Display

The instruments and equipment of this technology are intended for life support monitoring, submersible positioning and guidance, and construction site selection. Life support instruments are those required for the one-atmosphere chamber of submersibles and are addressed to the problems peculiar to this application; namely, atmospheric contaminant monitoring, limited power consumption, and limited space and weight requirements. This is also true for the submersible positioning and guidance instruments. Construction site selection instruments deal with those instruments necessary to obtain the required environmental data to resolve or select a construction site for a seafloor installation such as an acoustic array or habitat.

VIII. Load Handling and Transportation

This technology explores the capabilities necessary to transport, position, guide, lift, and lower heavy objects to depths of 12,000 feet. It addresses three problem areas: lifting and lowering, near-bottom transport and positioning, and guidance. The guidance systems presented are those required for lifting and lowering as well as near-bottom transport and positioning.

IX. Life Support and Related Systems

This technology examines the life support systems, including a safe and habitable one-atmosphere environment in a submersible pressure hull for 8 to 10 men capable of operating up to 30 days. Other systems include oxygen supply, carbon dioxide removal, emergency breathing, atmospheric contaminant removal, temperature and humidity control, and waste removal. Although life support systems are often considered well within the state-of-the-art, consideration of the requirements for compact, low-power, long-duration, safe systems are examined in this technology area.

APPENDIX A

TECHNOLOGY AREA I. MATERIALS AND STRUCTURES

SUB-TECHNOLOGY AREAS:

A. Massive Glass
B. Fiber Reinforced Plastics
C. Concrete
D. Metals
E. Buoyancy Materials
F. Miscellaneous
G. Structures

IA Sub-Technology: Massive Glass

Objective: To develop massive glass structures capable of operating down to 20,000-ft depths for at least 2,000 cycles. (The W/D ratio indicates the weight-to-displacement ratio of a spherical hull fabricated from the given material, near-perfect and free of residual stresses, which would collapse at the given depth.).

NOTE: All diameters are outside.

Events IA01 - IA10 address this objective.

DOT ASSESSMENT RESULTS

EVENT: IA01 Flotation structures (hollow spheres) to 10 inches in diameter. Compressive strength of 10 ksi (kilopounds per square inch); (W/D of 0.46); 95% reliability at a 90% lower level of confidence (e.g., no more than 5 spheres in each lot of 100 will fail during 2,000 cycles for 90 out of 100 lots).

SYSTEM CRITICALITY

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	18		0 %	
DESIRABLE		11	75 %	DESIRABLE
UNNECESSARY		7	25 %	

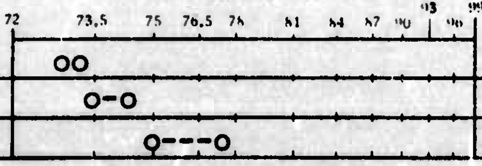
DEGREE OF RISK

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE	9		64 %	.1
.4 EXPERIMENTAL		9	36 %	
.7 SIMULATION			0 %	
.9 UNPROVEN			0 %	

DESIRED COURSE OF ACTION

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			100 %	SHORT
MEDIUM			0 %	
LONG			0 %	
UNDESIRABLE			0 %	

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	.6	73	73	1/2 - 1 1/2 YRS.
11	MOST LIKELY	1.0	74	74	1 1/2 - 2 1/2 YRS.
11	NOT LATER THAN	2.1	74,78	76.2	3 - 5 1/2 YRS.

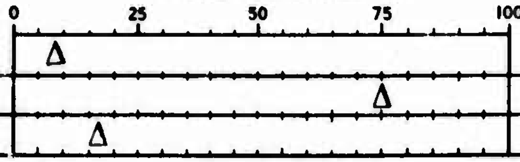
ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	.3	.2 M	.30 M	.13 - .47
10	UPPER LIMIT	.8	.5 M	.93 M	.43 - 1.43

DOT ASSESSMENT RESULTS

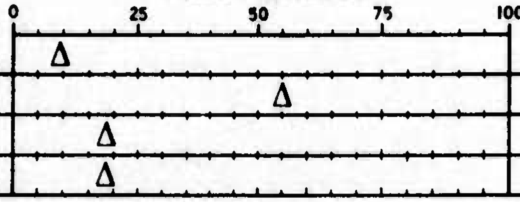
EVENT: IA02 Flotation structures (hollow spheres) 10 inches in diameter. Compressive strength of 100 ksi; (W/D of 0.46); 99.9% reliability,...same as IA01...

SYSTEM CRITICALITY



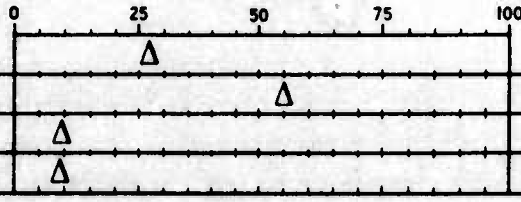
N- 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL			8 %	
DESIRABLE		8	75 %	DESIRABLE
UNNECESSARY	8		17 %	

DEGREE OF RISK



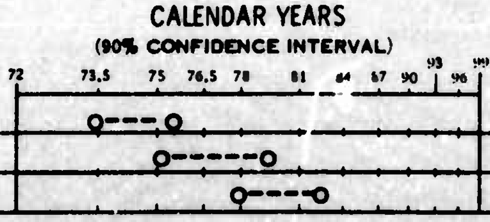
N- 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE		9	9 %	
.4 EXPERIMENTAL	15		55 %	.4
.7 SIMULATION	2		18 %	
.9 UNPROVEN		8	18 %	

DESIRED COURSE OF ACTION



N- 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			27 %	
MEDIUM			55 %	MEDIUM
LONG			9 %	
UNDESIRABLE			9 %	

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	2.0	74	74.6	1 1/2 - 4 YRS.
10	MOST LIKELY	3.3	75	76.9	3 - 7 YRS.
9	NOT LATER THAN	3.8	80	80.3	6 - 10 1/2 YRS.

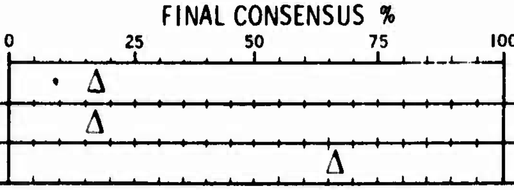
ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	.6	1 M	1.03 M	.67 - 1.40
10	UPPER LIMIT	1.8	5 M	3.05 M	2.03 - 4.07

DOT ASSESSMENT RESULTS

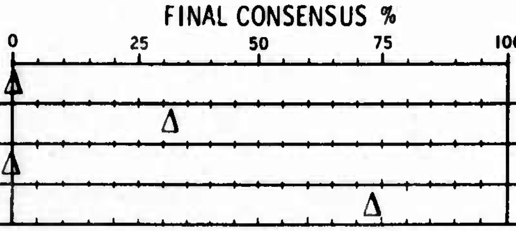
EVENT: IA03 Flotation structures (hollow spheres) 10 inches in diameter. Compressive strength of 300 ksi; (W/D of 0.15); 95% reliability...same as IA02.

SYSTEM CRITICALITY



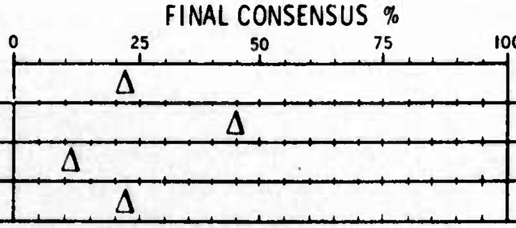
N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	8		17 %	
DESIRABLE			17 %	
UNNECESSARY		8	66 %	UNNECESSARY

DEGREE OF RISK



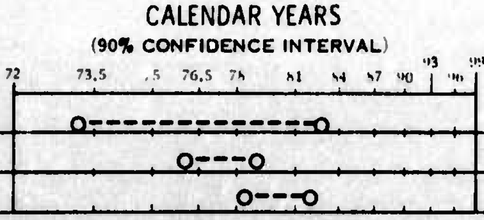
N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL			27 %	
.7 SIMULATION	9		0 %	
.9 UNPROVEN		9	73 %	.9

DESIRED COURSE OF ACTION



N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	13		22 %	
MEDIUM		12	45 %	MEDIUM
LONG			11 %	
UNDESIRABLE		1	22 %	

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	7.9	76	78.1	1 - 11 YRS.
8	MOST LIKELY	2.3	80	77.8	4 - 7 1/2 YRS.
8	NOT LATER THAN	2.6	80	80.5	6 1/2 - 10 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	2.9	.5,2 M	1.83M	.007 - 3.66
8	UPPER LIMIT	1.8	1 M	2.12M	.91 - 3.34

DOT ASSESSMENT RESULTS

EVENT: IA04 Flotation structures (hollow spheres) 10 inches in diameter. Compressive strength of 300 ksi; (W/D of 0.15); 99.9% reliability...same as IA03.

SYSTEM CRITICALITY

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	8		17 %	
DESIRABLE			8 %	
UNNECESSARY		8	75 %	UNNECESSARY

DEGREE OF RISK

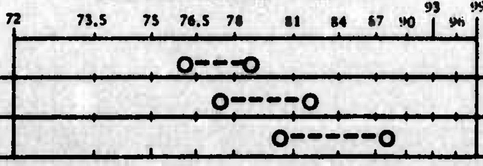
N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL			0 %	
.7 SIMULATION			18 %	
.9 UNPROVEN			82 %	.9

DESIRED COURSE OF ACTION

N= 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	12.5		0 %	
MEDIUM			50 %	MEDIUM
LONG		12.5	25 %	
UNDESIRABLE			25 %	

PROBABLE TIMING

CALENDAR YEARS
(90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
7	EARLIEST	2.3	75,80	76.7	4 - 6 1/2 YRS.
7	MOST LIKELY	3.4	80,85	80.1	5 1/2 - 10 1/2 YRS.
7	NOT LATER THAN	4.5	85	84.0	8 1/2 - 15 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
7	LOWER LIMIT	1.0	1 M	1.44 M	.69 - 2.20
7	UPPER LIMIT	1.7	5 M	3.54 M	2.26 - 4.81

DOT ASSESSMENT RESULTS

EVENT: IA05 Unmanned equipment capsules 36 inches in diameter. Compressive strength of 100 ksi; (W/D of 0.46); 95% reliability at 95% lower level of confidence.

SYSTEM CRITICALITY

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL	9		Δ	8 %	
DESIRABLE		26	Δ	84 %	DESIRABLE
UNNECESSARY	17		Δ	8 %	

DEGREE OF RISK

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL	18		Δ	18 %	
.7 SIMULATION		9	Δ	64 %	.7
.9 UNPROVEN		9	Δ	18 %	

DESIRED COURSE OF ACTION

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL		9	Δ	9 %	
MEDIUM		1	Δ	91 %	MEDIUM
LONG	10		Δ	0 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	o---o	2.0	74	75.3	2 - 4 1/2 YRS.
11	MOST LIKELY	o----o	2.9	76	78.2	4 1/2 - 8 YRS.
10	NOT LATER THAN	o--o	2.4	78	79.3	6 - 8 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

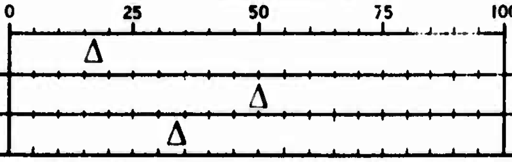
N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	1.3	.5,2 M	1.62 M	.88 - 2.36
10	UPPER LIMIT	2.1	5 M	3.56 M	2.34 - 4.78

DOT ASSESSMENT RESULTS

EVENT: IA06 Unmanned equipment capsules 36 inches in diameter. Compressive strength of 300 ksi; (W/D of 0.15); 95% reliability...same as IA05.

SYSTEM CRITICALITY

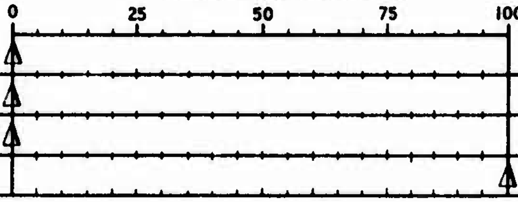
FINAL CONSENSUS %



N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	%	CONCLUSION
ESSENTIAL	8		17 %	
DESIRABLE			50 %	DESIRABLE
UNNECESSARY		8	33 %	

DEGREE OF RISK

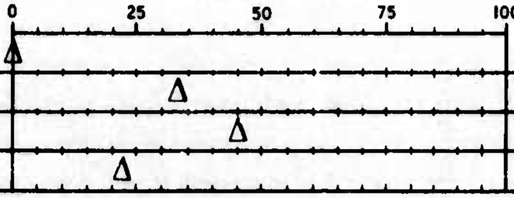
FINAL CONSENSUS %



N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	%	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL	9		0 %	
.7 SIMULATION			0 %	
.9 UNPROVEN		9	100 %	.9

DESIRED COURSE OF ACTION

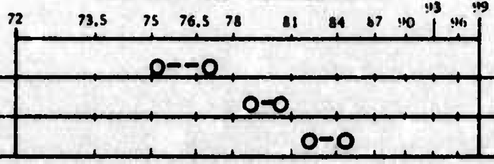
FINAL CONSENSUS %



N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	%	CONCLUSION
SHORT RANGE GOAL			0 %	
MEDIUM	11.5		33 %	
LONG		0.5	45 %	LONG
UNDESIRABLE		11	22 %	

PROBABLE TIMING

CALENDAR YEARS
(90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
8	EARLIEST	1.5	75,76	76.3	3 - 5 1/2 YRS.
8	MOST LIKELY	1.6	80	79.8	6 1/2 - 9 YRS.
8	NOT LATER THAN	2.1	85	83.5	10 - 13 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
8	LOWER LIMIT	1.8	2 M	2.56M	1.36 - 3. 76
8	UPPER LIMIT	2.7	5 M	5.75M	3.95 - 7.55

DOT ASSESSMENT RESULTS

EVENT: IA07 Manned spherical structural hulls 7 ft in diameter. Compressive strength of 100 ksi; (W/D of 0.46); 99.9% reliability...same as IA06.

SYSTEM CRITICALITY

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %		CONCLUSION
ESSENTIAL		8		58 %	ESSENTIAL
DESIRABLE	8			25 %	
UNNECESSARY				17 %	

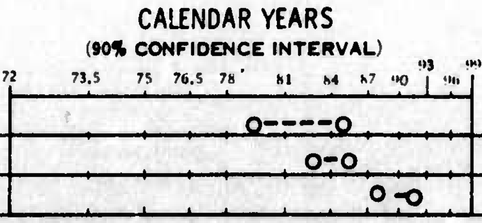
DEGREE OF RISK

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %		CONCLUSION
.1 PROTOTYPE	9			0 %	
.4 EXPERIMENTAL				0 %	
.7 SIMULATION				0 %	
.9 UNPROVEN		9		100 %	.9

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %		CONCLUSION
SHORT RANGE GOAL	11			0 %	
MEDIUM		5		50 %	MEDIUM
LONG	3			30 %	
UNDESIRABLE		9		20 %	

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	6.1	80	82.6	7 - 14 YRS.
9	MOST LIKELY	1.8	85	84.7	11 1/2 - 14 YRS.
9	NOT LATER THAN	1.6	90	89.2	16 - 18 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	9.4	10 M	10.9 M	5.42 - 16.38
9	UPPER LIMIT	11.6	10,20 M	18.11M	10.93 - 25.29

DOT ASSESSMENT RESULTS

EVENT: IA08 Manned spherical hulls 7 ft in diameter. Compressive strength of 300 ksi; (W/D of 0.15); 99.9% reliability ...same as IA07.

SYSTEM CRITICALITY

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	4.5		45.5%	ESSENTIAL
DESIRABLE		9	9 %	
UNNECESSARY	4.5		45.5%	UNNECESSARY

DEGREE OF RISK

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL			0 %	
.7 SIMULATION			0 %	
.9 UNPROVEN			100 %	.9

DESIRED COURSE OF ACTION

N= 7	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			0 %	
MEDIUM	12.5		0 %	
LONG	4		71 %	LONG
UNDESIRABLE		16.5	29 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
7	EARLIEST	3.5	85	81.6	7 - 12 YRS.
7	MOST LIKELY	2.9	85	85.7	11 1/2 - 16 YRS.
7	NOT LATER THAN	2.3	90	91.4	18 - 21 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
7	LOWER LIMIT	10.6	[illegible] M	12.57M	4.75 - 20.39
7	UPPER LIMIT	19.2	10.[illegible] M	2929 M	15.22 - 43.36

DOT ASSESSMENT RESULTS

EVENT: IA09

Joint design which permits opening and closing of a glass hemisphere to be mated to another glass hemisphere such that the complete structure can mobilize the entire strength of the glass. 99.9% reliability...same as IA08.

SYSTEM CRITICALITY

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL	9			64 %	ESSENTIAL
DESIRABLE		9		36 %	
UNNECESSARY				0 %	

DEGREE OF RISK

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE				0 %	
.4 EXPERIMENTAL				27 %	
.7 SIMULATION	9			18 %	
.9 UNPROVEN		9		55 %	.9

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL		4.5		50 %	SHORT
MEDIUM	5.5			40 %	
LONG		1		10 %	
UNDESIRABLE				0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST		2.6	74	76.2	2½ - 5½ YRS.
10	MOST LIKELY		4.3	76.85	79.9	5½ - 10½ YRS.
9	NOT LATER THAN		5.6/	90	82.9	7½ - 14½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	7.0	1.2 M	4.43M	.36 - 8.50
10	UPPER LIMIT	28.2	5.10 M	16.36M	.03 - 32.69

DOT ASSESSMENT RESULTS

EVENT: IA10 Joint design which permits a glass hemisphere to be mated to a cylinder fabricated from another material (such as Titanium) and that the complete structure can mobilize the entire strength of both materials. 99.9% reliability... same as IA09.

SYSTEM CRITICALITY

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL		9.5		64 %	ESSENTIAL
DESIRABLE	9.5			36 %	
UNNECESSARY				0 %	

DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE				0 %	
.4 EXPERIMENTAL	8			20 %	
.7 SIMULATION		4		40 %	.7
.9 UNPROVEN		4		40 %	.9

DESIRED COURSE OF ACTION

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL	12.5			33 %	
MEDIUM		10.5		56 %	MEDIUM
LONG		2		11 %	
UNDESIRABLE				0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST		2.7	74	76.8	3 - 6½ YRS.
9	MOST LIKELY		3.7	76,85	79.4	5 - 10 YRS.
9	NOT LATER THAN		4.8	85	82.6	7½ - 13½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	7.0	1 M	4.53 M	.47 - 8.59
10	UPPER LIMIT	28.2	5,10 M	16.66 M	.32 - 33.00

IB Sub-Technology: Fiber Reinforced Plastics

Objective: To develop fiber reinforced plastic structures capable of operating down to 20,000-ft depths for at least 2,000 cycles of 100 hours each. (The W/D ratio indicates the weight-to-displacement ratio of a cylindrical hull fabricated from the given material, near-perfect and free of residual stresses, which would collapse at the given depth.)

Events IB01 - IB11 address this objective.

DOT ASSESSMENT RESULTS

EVENT: IB01 Unmanned cylindrical equipment capsules, 6 inches in diameter, fabricated from glass reinforced plastic, with hemispherical end closures fabricated from another material such as Titanium. Compressive strength 150 ksi; (W/D of 0.55); 95% reliability at a 95% lower level of confidence.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL			Δ	10 %	
DESIRABLE			Δ	90 %	DESIRABLE
UNNECESSARY			Δ	0 %	

DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE		10	Δ	10 %	
.4 EXPERIMENTAL	20		Δ	30 %	
.7 SIMULATION		10	Δ	60 %	.7
.9 UNPROVEN			Δ	0 %	

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL		10	Δ	20 %	
MEDIUM	10		Δ	80 %	MEDIUM
LONG			Δ	0 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	o-----o	2.0	75	74.9	1 1/2 - 4 YRS.
10	MOST LIKELY	o-------o	3.5	78	77.6	3 1/2 - 7 1/2 YRS.
9	NOT LATER THAN	o---o	3.0	80	79	5 - 9 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	.5	.1, .2M	.40 M	.07 - .72
9	UPPER LIMIT	.3	.5 M	.51 M	.35 - .67

DOT ASSESSMENT RESULTS

EVENT: IB02 Unmanned cylindrical equipment capsules, 36 inches in diameter, fabricated from glass reinforced plastic, with hemispherical end closures fabricated from another material such as Titanium. Compressive strength 230 ksi; (W/D of 0.35); 95% reliability...same as IB01.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL			0 %	
DESIRABLE	10		70 %	DESIRABLE
UNNECESSARY		10	30 %	

DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL			10 %	
.7 SIMULATION			60 %	.7
.9 UNPROVEN			30 %	

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			0 %	
MEDIUM			60 %	MEDIUM
LONG	10		10 %	
UNDESIRABLE		10	30 %	

PROBABLE TIMING

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	2.4	76,80	76.8	3 1/2 - 6 1/2 YRS.
9	MOST LIKELY	4.5	80	80.7	6 - 11 1/2 YRS
9	NOT LATER THAN	5.7	85	83.9	8 1/2 - 15 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	1.9	2 M	1.97 M	.79 - 3.14
9	UPPER LIMIT	3.6	5 M	4.18 M	1.92 - 6.44

DOT ASSESSMENT RESULTS

EVENT: IB03

Manned cylindrical structural hulls, 7 ft in diamter, fabricated from glass reinforced plastic, with end closures which may be another material. Compressive strength 150 ksi; (W/D of 0.55); 99.9% reliability... same as IB02.

SYSTEM CRITICALITY

N· 10	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
ESSENTIAL			Δ	50 %	ESSENTIAL
DESIRABLE	10		Δ	40 %	
UNNECESSARY		10	Δ	10 %	

DEGREE OF RISK

N· 9	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL	15		Δ	45 %	.4
.7 SIMULATION		13	Δ	33 %	
.9 UNPROVEN		2	Δ	22 %	

DESIRED COURSE OF ACTION

N· 10	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
SHORT RANGE GOAL			Δ	0 %	
MEDIUM	10		Δ	40 %	
LONG			Δ	50 %	LONG
UNDESIRABLE		10	Δ	10 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	o---o	1.9	75,76	76.8	3 1/2 - 6 YRS.
9	MOST LIKELY	o----o	4.0	80	80.2	5 1/2 - 10 1/2 YRS.
9	NOT LATER THAN	o------o	6.6	77,82	84.3	8 - 16 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	2.8	2 M	2.82 M	1.07 - 4.57
9	UPPER LIMIT	29.5	10 M	17.1 M	0 - 35.38

DOT ASSESSMENT RESULTS

EVENT: IB04

Manned cylindrical structural hulls, 7 ft in diameter, fabricated from glass reinforced plastic, with end closures which may be another material. Compressive strength of 230 ksi; (W/D of 0.35); 99.9% reliability... same as IB03.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	10		30 %	
DESIRABLE			30 %	
UNNECESSARY		10	40 %	UNNECESSARY

DEGREE OF RISK

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL	10		0 %	
.7 SIMULATION		3	33 %	
.9 UNPROVEN		7	67 %	.9

DESIRED COURSE OF ACTION

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			0 %	
MEDIUM	19		11 %	
LONG		4.5	44.5 %	
UNDESIRABLE		14.5	44.5 %	UNDESIRABLE

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
7	EARLIEST	1.6	80	79	6 - 8 YRS.
7	MOST LIKELY	3.2	85	84.1	10 - 14 1/2 YRS.
7	NOT LATER THAN	4.3	90	89.9	14 1/2 - 21 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
6	LOWER LIMIT	2.9	10 M	7.17 M	4.77 - 9.56
6	UPPER LIMIT	31.8	20 M	30 M	3.88 - 56.12

DOT ASSESSMENT RESULTS

EVENT: IB05

Unmanned cylindrical equipment capsules, 36 inches in diameter, fabricated from graphite reinforced plastic, with hemispherical end closures fabricated from another material such as Titanium. Compressive strength 70 ksi; (W/D of 1.1); 95% reliability...same as IB04.

SYSTEM CRITICALITY

N° 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	10		0 %	
DESIRABLE			40 %	
UNNECESSARY		10	60 %	UNNECESSARY

DEGREE OF RISK

N° 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL			11 %	
.7 SIMULATION	11		11 %	
.9 UNPROVEN		11	78 %	.9

DESIRED COURSE OF ACTION

N° 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			0 %	
MEDIUM		3	78 %	MEDIUM
LONG			0 %	
UNDESIRABLE	3		22 %	

PROBABLE TIMING

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	1.6	76	75.9	3 - 5 YRS.
9	MOST LIKELY	2.7	77.78	79	5 1/2 - 8 1/2 YRS.
8	NOT LATER THAN	3.8	80	81.8	7 - 12 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	.8	.3 M	.81 M	.30 - 1.33
8	UPPER LIMIT	3.0	2 M	2.33 M	.33 - 4.32

DOT ASSESSMENT RESULTS

EVENT: IB06 Unmanned cylindrical equipment capsules, 36 inches in diameter, fabricated from graphite reinforced plastic, with hemispherical end closures fabricated from another material such as Titanium. Compressive strength 130 ksi; (W/D of 0.6); 95% reliability...same as IB05.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL			10 %	
DESIRABLE		10	80 %	DESIRABLE
UNNECESSARY	10		10 %	

DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL			0 %	
.7 SIMULATION	10		20 %	
.9 UNPROVEN		10	80 %	.9

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			0 %	
MEDIUM	7		60 %	MEDIUM
LONG		8	30 %	
UNDESIRABLE	1		10 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL)	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	o--o	1.7	77,78	77.7	4 1/2 - 6 1/2 YRS.
9	MOST LIKELY	o--o	3.0	80,82	81	7 - 11 YRS.
9	NOT LATER THAN	o--o	3.6	85	84	10 - 14 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	.4	1 M	1 M	.71 - 1.29
9	UPPER LIMIT	2.7	5 M	3.89 M	2.22 - 5.55

DOT ASSESSMENT RESULTS

EVENT: IB07 Manned cylindrical structural hulls, 7 ft in diameter, fabricated from graphite reinforced plastic, with end closures which may be another material. Compressive strength 70 ksi; (W/D of 1.1); 99.9% reliability... same as IB06.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL	10			0 %	
DESIRABLE				50 %	
UNNECESSARY		10		50 %	UNNECESSARY

DEGREE OF RISK

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE				0 %	
.4 EXPERIMENTAL				0 %	
.7 SIMULATION				11 %	
.9 UNPROVEN				89 %	.9

DESIRED COURSE OF ACTION

N= 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL				0 %	
MEDIUM	12.5			12.5 %	
LONG	12.5			50 %	LONG
UNDESIRABLE		25		37.5 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
8	EARLIEST		2.3	78,80	79.5	6 - 9 YRS.
7	MOST LIKELY		3.8	80	83.6	8 1/2 - 14 1/2 YRS.
7	NOT LATER THAN		5.5	85,90	88	12 - 20 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
8	LOWER LIMIT	7.7	2,3 M	7.56 M	2.53 - 12.60
7	UPPER LIMIT	34.3	5 M	25.29 M	.75 - 49.82

DOT ASSESSMENT RESULTS

EVENT: IB08	Manned cylindrical structural hulls, 7 ft in diameter, fabricated from graphite reinforced plastic, with end closures which may be another material. Compressive strengtʰ 130 ksi; (W/D of 0.6); 99.9% reliability... same as IB07.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	10		0 %	
DESIRABLE		20	90 %	DESIRABLE
UNNECESSARY	10		10 %	

DEGREE OF RISK

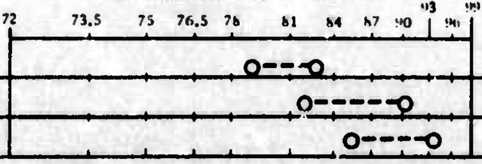
N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL			0 %	
.7 SIMULATION		20	30 %	
.9 UNPROVEN	20		70 %	.9

DESIRED COURSE OF ACTION

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			0 %	
MEDIUM		1	11 %	
LONG	2		78 %	LONG
UNDESIRABLE		1	11 %	

PROBABLE TIMING

CALENDAR YEARS
(90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
8	EARLIEST	3.1	80,85	81.3	7 - 11 1/2 YRS.
8	MOST LIKELY	4.7	85	86	11 - 17 YRS.
8	NOT LATER THAN	5.2	90	90.1	14 1/2 - 21 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
8	LOWER LIMIT	8.5	10 M	9.25 M	3.57 - 14.93
8	UPPER LIMIT	30.3	NoneM	28.63 M	8.32 - 48.93

DOT ASSESSMENT RESULTS

EVENT: IB09 Non-destructive test methods and equipment which ensure that a given fiber reinforced plastic structure will perform as designed.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL			Δ	90 %	ESSENTIAL
DESIRABLE			Δ	10 %	
UNNECESSARY			Δ	0 %	

DEGREE OF RISK

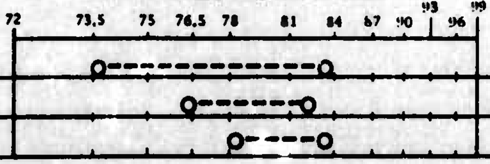
N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL			Δ	60 %	.4
.7 SIMULATION		10	Δ	30 %	
.9 UNPROVEN	10		Δ	10 %	

DESIRED COURSE OF ACTION

N= 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL		8	Δ	75 %	SHORT
MEDIUM	8		Δ	25 %	
LONG			Δ	0 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

CALENDAR YEARS
(90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	8.2	75	78.8	1 1/2 - 12 YRS.
8	MOST LIKELY	3.7	77	78.8	4 1/2 - 9 1/2 YRS.
8	NOT LATER THAN	4.2	80	81.1	6 1/2 - 12 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	3.0	1 M	2.48M	.62 - 4.34
8	UPPER LIMIT	15.8	2 M	8.84M	0 - 19.44

DOT ASSESSMENT RESULTS

EVENT: IB10 Structural design which permits major penetrations (hatches, viewports) in the fiber reinforced plastic structure.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL		10		90 %	ESSENTIAL
DESIRABLE	10			0 %	
UNNECESSARY				10 %	

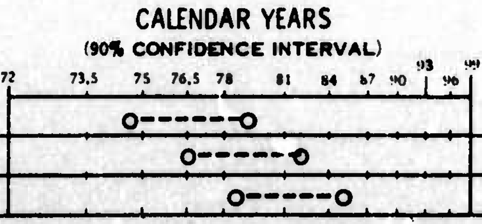
DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE				0 %	
.4 EXPERIMENTAL				30 %	
.7 SIMULATION		10		40 %	.7
.9 UNPROVEN	10			30 %	

DESIRED COURSE OF ACTION

N= 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL		12.5		62.5 %	SHORT
MEDIUM	5			25 %	
LONG				0 %	
UNDESIRABLE	7.5			12.5 %	

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	3.4	75	76.9	3 - 7 YRS.
8	MOST LIKELY	4.3	77	79.5	4 1/2 - 10 1/2 YRS.
8	NOT LATER THAN	4.9	78	82	6 1/2 - 13 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	1.4	1 M	1.70 M	.80 - 2.60
8	UPPER LIMIT	3.0	2 M	3.21 M	1.22 - 5.20

DOT ASSESSMENT RESULTS

EVENT: IB11 Structural design which permits fiber reinforced plastic end closures for fiber reinforced plastic cylindrical structures.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	10		20 %	
DESIRABLE		10	70 %	DESIRABLE
UNNECESSARY			10 %	

DEGREE OF RISK

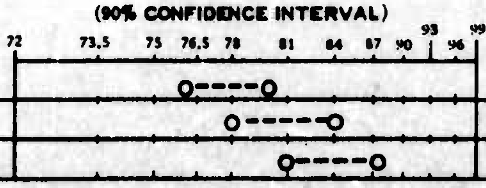
N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL			40 %	.4
.7 SIMULATION		10	20 %	
.9 UNPROVEN	10		40 %	

DESIRED COURSE OF ACTION

N= 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	22		0 %	
MEDIUM		20.5	87.5 %	MEDIUM
LONG			0 %	
UNDESIRABLE		1.5	12.5 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
8	EARLIEST	3.3	75,80	78.4	4 - YRS.
7	MOST LIKELY	4.1	77	81.0	6 - 12 YRS.
7	NOT LATER THAN	4.2	80	84	9 - 15 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	1.8	.2 M	1.73 M	.59 - 2.88
8	UPPER LIMIT	3.2	None M	3.61 M	1.44 - 5.78

IC Sub-Technology· Concrete

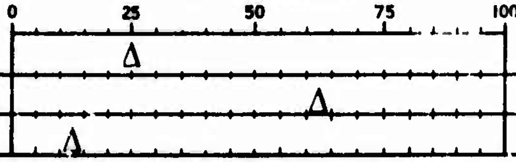
Objective: To develop concrete pressure resistant structures capable of fixed operation at the given depth for a period of at least 10 years.

Events IC01 - IC07 address this objective.

DOT ASSESSMENT RESULTS

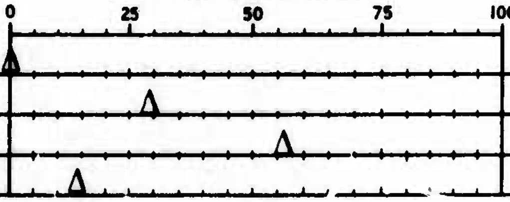
EVENT: IC01 Manned spherical structures 20 ft in diameter, for operation at a depth of 1,000 ft. Compressive strength of 10,000 psi; 99.9% reliability at a 95% lower level confidence.

SYSTEM CRITICALITY



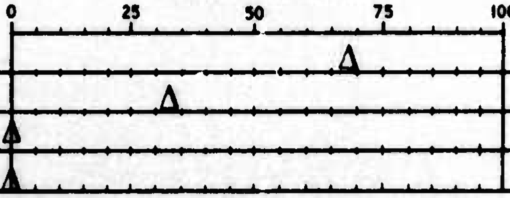
N- 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	4		25 %	
DESIRABLE		20.5	62.5 %	DESIRABLE
UNNECESSARY	16.5		12.5 %	

DEGREE OF RISK



N- 7	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE	17		0 %	
.4 EXPERIMENTAL	4		29 %	
.7 SIMULATION		7	57 %	.7
.9 UNPROVEN		14	14 %	

DESIRED COURSE OF ACTION

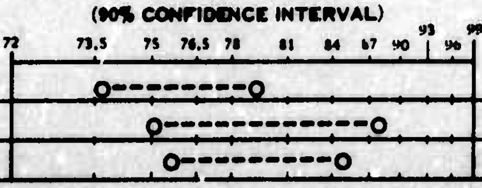


N- 6	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	4		67 %	SHORT
MEDIUM		4	33 %	
LONG			0 %	
UNDESIRABLE			0 %	

PROBABLE TIMING

CALENDAR YEARS

(90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
7	EARLIEST	3.9	75	76.7	2 - 7 1/2 YRS.
7	MOST LIKELY	8.3	None	81.3	3 - 15 1/2 YRS.
6	NOT LATER THAN	5.3	None	80.2	4 - 12 1/2 YRS.

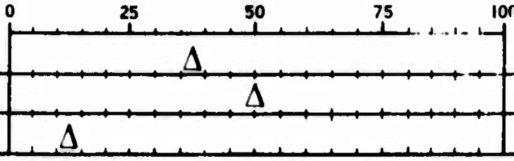
ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
7	LOWER LIMIT	2.0	.5 M	2.11 M	.63 - 3.60
6	UPPER LIMIT	17.9	2 M	10.03M	0 - 24.79

DOT ASSESSMENT RESULTS

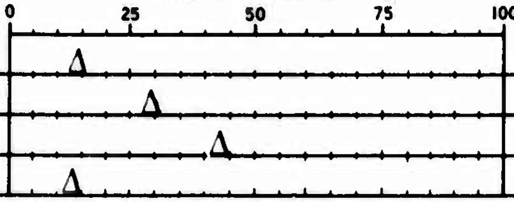
EVENT: IC02 — Manned cylindrical structures, 10 ft in diameter, for operation at a depth of 1,000 ft. Compressive strength of 10,000 psi; 99.9% reliability...same as IC01.

SYSTEM CRITICALITY



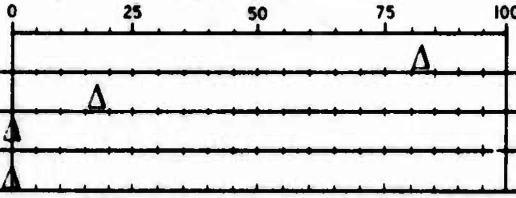
N = 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL		8.5	37.5 %	
DESIRABLE	7		50 %	DESIRABLE
UNNECESSARY	1.5		12.5 %	

DEGREE OF RISK



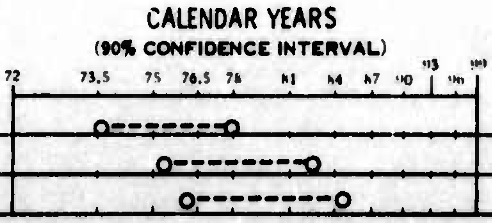
N = 7	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE	3		14 %	
.4 EXPERIMENTAL	4		29 %	
.7 SIMULATION	7		43 %	.7
.9 UNPROVEN		14	14 %	

DESIRED COURSE OF ACTION



N = 6	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			83 %	SHORT
MEDIUM			17 %	
LONG			0 %	
UNDESIRABLE			0 %	

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
7	EARLIEST	2.9	75	75.7	1 1/2 - 6 YRS.
7	MOST LIKELY	4.4	85	78.9	3 1/2 - 10 YRS.
6	NOT LATER THAN	5.2	75	80.3	4 - 12 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
7	LOWER LIMIT	1.5	.5,2 M	1.56 M	.41 - 2.70
6	UPPER LIMIT	18.1	1 M	9.57 M	0 - 24.47

DOT ASSESSMENT RESULTS

EVENT: IC03 Manned spherical structures, 20 ft in diameter, for operation at a depth of 3,000 ft. Compressive strength of 10,000 psi; 99.9% reliability...same as IC02.

SYSTEM CRITICALITY

N= 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	4		25 %	
DESIRABLE		5.5	62.5 %	DESIRABLE
UNNECESSARY	1.5		12.5 %	

DEGREE OF RISK

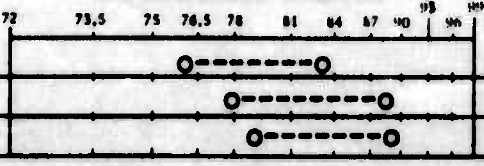
N= 7	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE	17		0 %	
.4 EXPERIMENTAL	4		29 %	
.7 SIMULATION		9	42 %	.7
.9 UNPROVEN		12	29 %	

DESIRED COURSE OF ACTION

N= 6	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			17 %	
MEDIUM			83 %	MEDIUM
LONG			0 %	
UNDESIRABLE			0 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
7	EARLIEST	5.3	75,77	79.9	4 - 11 1/2 YRS.
7	MOST LIKELY	7.4	None	83.3	6 -16 1/2 YRS.
6	NOT LATER THAN	6.2	None	84.3	7 - 17 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

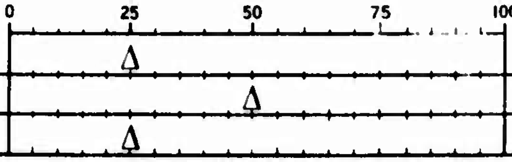
N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
7	LOWER LIMIT	6.8	1 M	5.33 M	.36 - 10.30
6	UPPER LIMIT	17.8	2 M	10.42M	0 - 25.04

DOT ASSESSMENT RESULTS

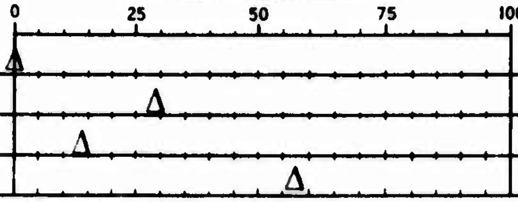
EVENT: IC04

Manned cylindrical structures, 10 ft in diameter, for operation a a depth of 2,000 ft. Compressive strength of 20,000 psi; 99.9% reliability...same as IC03.

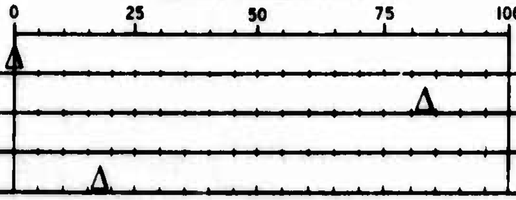
SYSTEM CRITICALITY

N= 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %		CONCLUSION
ESSENTIAL	4			25 %	
DESIRABLE		8		50 %	DESIRABLE
UNNECESSARY	4			25 %	

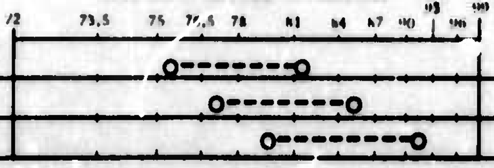
DEGREE OF RISK

N= 7	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %		CONCLUSION
.1 PROTOTYPE	17			0 %	
.4 EXPERIMENTAL		12		29 %	
.7 SIMULATION	19			14 %	
.9 UNPROVEN		24		57 %	.9

DESIRED COURSE OF ACTION

N= 6	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %		CONCLUSION
SHORT RANGE GOAL	17			0 %	
MEDIUM		17		83 %	MEDIUM
LONG	17			0 %	
UNDESIRABLE		17		17 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL)	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
6	EARLIEST		3.4	75	78.3	3 1/2 - 9 YRS.
6	MOST LIKELY		4.7	None	80.8	5 - 12 1/2 YRS
6	NOT LATER THAN		5.8	None	85.3	8 1/2 - 18 YRS.

ESTIMATED COSTS TO ACHIEVE

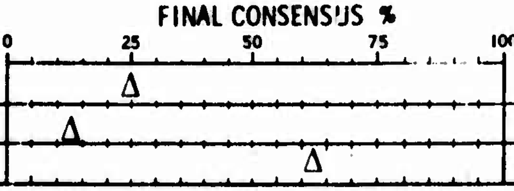
N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
6	LOWER LIMIT	3.4	.5 M	2.38M	0 - 5.22
6	UPPER LIMIT	17.9	2 M	9.93M	0 - 24.70

DOT ASSESSMENT RESULTS

EVENT: IC05

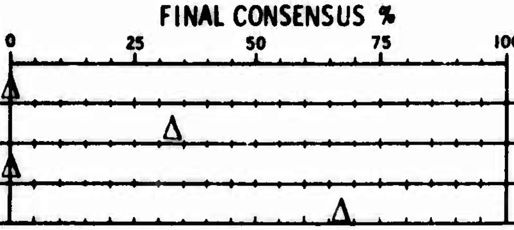
Manned spherical structures, 20 ft in diameter, for operation at a depth of 6,000 ft. Compressive strength of 20,000 psi using reinforced concrete or polymer-impregnated concrete; 99.9% reliability...same as IC04.

SYSTEM CRITICALITY



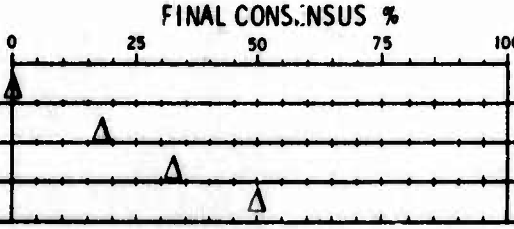
N- 8	PERCENTAGE		FINAL CONSENSUS %	CONCLUSION
	LOSS	GAIN		
ESSENTIAL	4		25 %	
DESIRABLE	16.5		12.5 %	
UNNECESSARY		20.5	62.5%	UNNECESSARY

DEGREE OF RISK



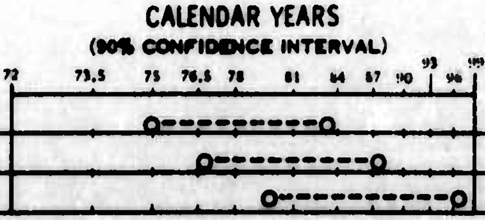
N- 6	PERCENTAGE		FINAL CONSENSUS %	CONCLUSION
	LOSS	GAIN		
.1 PROTOTYPE	20		0 %	
.4 EXPERIMENTAL		13	33 %	
.7 SIMULATION	20		0 %	
.9 UNPROVEN		27	67 %	.9

DESIRED COURSE OF ACTION



N- 6	PERCENTAGE		FINAL CONSENSUS %	CONCLUSION
	LOSS	GAIN		
SHORT RANGE GOAL	17		0 %	
MEDIUM			17 %	
LONG			33 %	
UNDESIRABLE		17	50 %	UNDESIRABLE

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
5	EARLIEST	4.6	75.85	79.4	3 - 12 YRS
5	MOST LIKELY	6.1	90	82.6	5 - 16 1/2 YRS
5	NOT LATER THAN	9.1	None	88.8	8 - 25 1/2 YRS

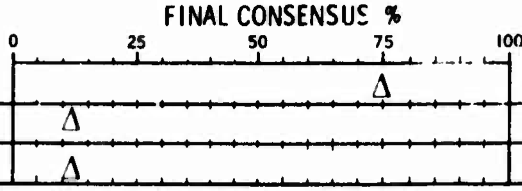
ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
5	LOWER LIMIT	19.1	1 M	12.46M	0 - 30.68
5	UPPER LIMIT	38.4	2 M	23.92M	0 - 60.53

DOT ASSESSMENT RESULTS

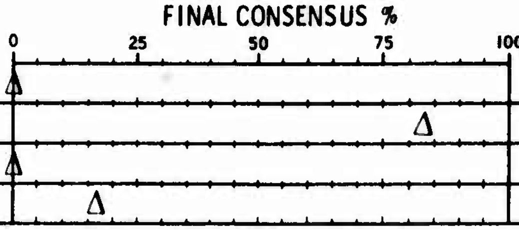
EVENT: IC06 Non-destructive test methods and equipment which ensure that a given concrete structure will perform as designed.

SYSTEM CRITICALITY



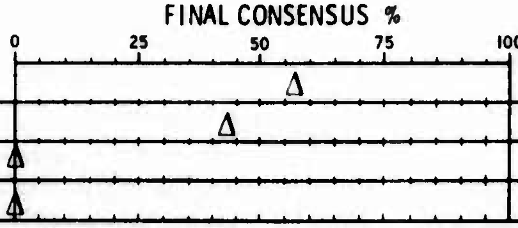
N= 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	11		75 %	ESSENTIAL
DESIRABLE		12.5	12.5 %	
UNNECESSARY	1.5		12.5 %	

DEGREE OF RISK



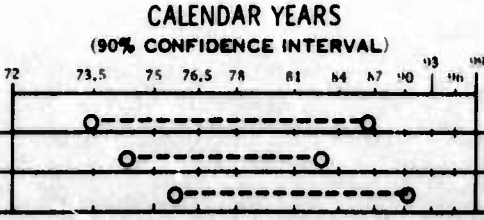
N= 6	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE	17		0 %	
.4 EXPERIMENTAL		17	83 %	.4
.7 SIMULATION			0 %	
.9 UNPROVEN			17 %	

DESIRED COURSE OF ACTION



N= 7	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		40	57 %	SHORT
MEDIUM	23		43 %	
LONG	17		0 %	
UNDESIRABLE			0 %	

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
7	EARLIEST	8.9	75	80	1 1/2 - 14 1/2 YRS.
6	MOST LIKELY	5.1	77	78.8	2 1/2 - 11 YRS.
6	NOT LATER THAN	8.0	80	82.5	4 - 17 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
7	LOWER LIMIT	1.6	.5 M	1.34 M	.17 - 2.52
6	UPPER LIMIT	1.8	1 M	2.05 M	.59 - 3.51

DOT ASSESSMENT RESULTS

EVENT: IC07 Structural design which will permit entry locks as large as 10 ft in diameter in a concrete structure.

SYSTEM CRITICALIT

N· 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL		16	Δ	50 %	ESSENTIAL
DESIRABLE	8		Δ	25 %	
UNNECESSARY		8	Δ	25 %	

DEGREE OF RISK

N· 5	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL	5		Δ	20 %	
.7 SIMULATION		10	Δ	60 %	.7
.9 UNPROVEN	5		Δ	20 %	

DESIRED COURSE OF ACTION

N· 7	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL		17	Δ	57 %	SHORT
MEDIUM		3	Δ	43 %	
LONG	20		Δ	0 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
6	EARLIEST	o------------o	5.1	73,78	77.5	1 1/2 - 9 1/2 YRS.
6	MOST LIKELY	o---------o	5.2	75	80.7	4 1/2 - 13 YRS.
6	NOT LATER THAN	o-----------o	8.1	77,90	86.5	8 - 21 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
7	LOWER LIMIT	.6	.1 M	.66 M	.17 - 1.15
6	UPPER LIMIT	1.7	1 M	2.20M	.78 - 3.62

ID Sub-Technology: Metals

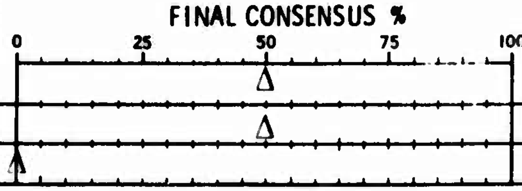
Objective: To develop metal structures capable of operating down to 20,000-ft depths for at least 2,000 cycles. (The W/D ratio indicates the weight-to-displacement ratio of a spherical hull fabricated from the given material, near-perfect and free of residual stresses, which would collapse at the given depth.)

Events ID01 - ID09 address this objective.

DOT ASSESSMENT RESULTS

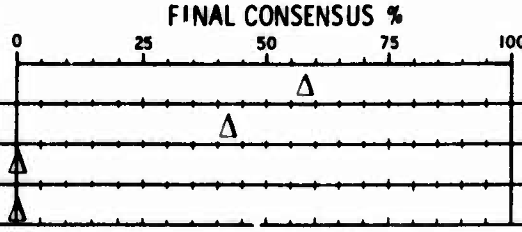
EVENT: ID01 Manned spherical structural hulls 7 ft in diameter, fabricated from Titanium. Yield strength of 100 ksi; (W/D of 0.88); 99.9% reliability at a 95% lower level of confidence.

SYSTEM CRITICALITY



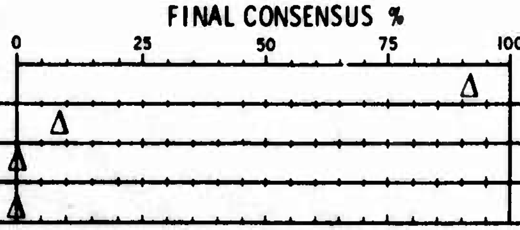
N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	9		50 %	
DESIRABLE		17	50 %	DESIRABLE
UNNECESSARY	8		0 %	

DEGREE OF RISK



N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE	6		58 %	.1
.4 EXPERIMENTAL		6	42 %	
.7 SIMULATION			0 %	
.9 UNPROVEN			0 %	

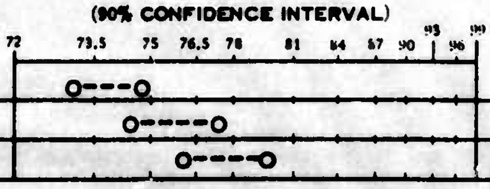
DESIRED COURSE OF ACTION



N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		2	92 %	SHORT
MEDIUM	2		8 %	
LONG			0 %	
UNDESIRABLE			0 %	

PROBABLE TIMING

CALENDAR YEARS
(90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	1.7	74	73.8	1 - 2 1/2 YRS.
12	MOST LIKELY	2.4	74,75	75.8	2 1/2 - 5 YRS.
12	NOT LATER THAN	3.4	77	77.8	4 - 7 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	3.9	1,2 M	2.75 M	.59 - 4.90
11	UPPER LIMIT	13.3	5 M	8.75 M	1.52 - 15.99

DOT ASSESSMENT RESULTS

EVENT: ID02 Manned spherical structural hulls 7 ft in diameter, fabricated from Titanium. Yield strength of 150 ksi; (W/D of 0.59); 99.9% reliability...same as ID01.

SYSTEM CRITICALITY

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL			8 %	
DESIRABLE			92 %	DESIRABLE
UNNECESSARY			0 %	

DEGREE OF RISK

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL			58 %	.4
.7 SIMULATION			25 %	
.9 UNPROVEN			17 %	

DESIRED COURSE OF ACTION

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	1		17 %	
MEDIUM		1	83 %	MEDIUM
LONG			0 %	
UNDESIRABLE			0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	o--o	2.0	75,77	76.5	3 1/2 - 5 1/2 YRS.
12	MOST LIKELY	o--o.	3.0	80	79.7	6 - 9 YRS.
12	NOT LATER THAN	o--o	3.8	85	83.8	10 - 14 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	7.3	20 M	9.20M	5.24 - 13.16
11	UPPER LIMIT	24.1	10 M	25.03M	11.86 - 38.19

DOT ASSESSMENT RESULTS

EVENT: ID03 Manned spherical structural hulls 7 ft in diameter, fabricated from Titanium. Yield strength of 185 ksi; (W/D of 0.48); 99.9% reliability...same as ID02.

SYSTEM CRITICALITY

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL			Δ	0 %	
DESIRABLE			Δ	75 %	DESIRABLE
UNNECESSARY			Δ	25 %	

DEGREE OF RISK

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL			Δ	17 %	
.7 SIMULATION	17		Δ	8 %	
.9 UNPROVEN		17	Δ	75 %	.9

DESIRED COURSE OF ACTION

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL			Δ	8 %	
MEDIUM			Δ	42 %	MEDIUM
LONG			Δ	25 %	
UNDESIRABLE			Δ	25 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73,5 75 76,5 78 81 84 87 90 93 96 100	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	o---o	4.3	77	80.4	6 - 10 1/2 YRS.
12	MOST LIKELY	o---o	5.6	85	84.8	10 - 15 1/2 YRS.
11	NOT LATER THAN	o---o	5.7	85,90	88.7	13 1/2 - 20 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	13.4	20 M	17.03 M	9.72 - 24.34
10	UPPER LIMIT	24.4	50 M	36.05M	21.91 - 50.19

DOT ASSESSMENT RESULTS

EVENT: ID04 Unmanned flotation structures (hollow spheres) 20 inches in diameter, fabricated from Titanium. Yield strength of 150 ksi; (W/D of 0.59); 95% reliability...same as ID03.

SYSTEM CRITICALITY

N= 12	PERCENTAGE		FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
	LOSS	GAIN			
ESSENTIAL			Δ	0 %	
DESIRABLE		17	Δ	100 %	DESIRABLE
UNNECESSARY	17		Δ	0 %	

DEGREE OF RISK

N= 12	PERCENTAGE		FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
	LOSS	GAIN			
.1 PROTOTYPE	1		Δ	8 %	
.4 EXPERIMENTAL		4	Δ	59 %	.4
.7 SIMULATION		7	Δ	25 %	
.9 UNPROVEN	10		Δ	8 %	

DESIRED COURSE OF ACTION

N= 12	PERCENTAGE		FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
	LOSS	GAIN			
SHORT RANGE GOAL		16	Δ	25 %	
MEDIUM	16		Δ	75 %	MEDIUM
LONG			Δ	0 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	o--o	1.1	75	74.4	2 - 3 YRS.
12	MOST LIKELY	o-o	1.5	77	76.8	4 - 5 1/2 YRS.
12	NOT LATER THAN	oo	1.6	80	79.6	7 - 8 1/2 YRS.

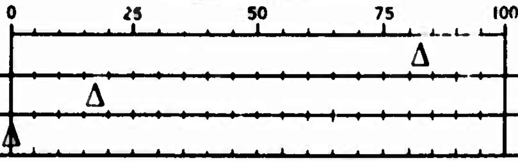
ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	.5	1 M	.86 M	.60 - 1.12
11	UPPER LIMIT	1.6	2,5 M	2.66 M	1.78 - 3.55

DOT ASSESSMENT RESULTS

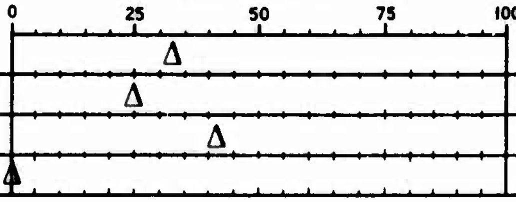
EVENT: ID05 Manned spherical structural hulls 7 ft in diameter, fabricated from steel. Yield strength of 180 ksi; (W/D of 0.78); 99.9% reliability...same as ID04.

SYSTEM CRITICALITY



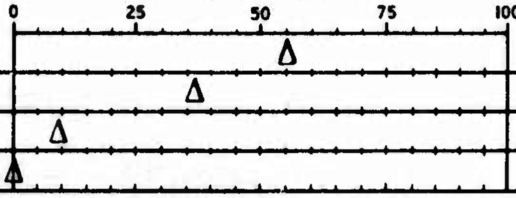
N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL		16	83 %	ESSENTIAL
DESIRABLE	16		17 %	
UNNECESSARY			0 %	

DEGREE OF RISK



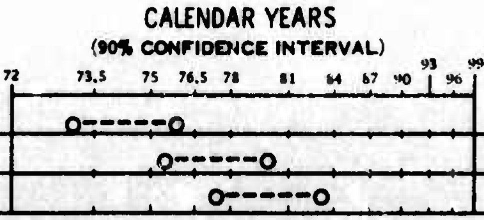
N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			33 %	
.4 EXPERIMENTAL	8		25 %	
.7 SIMULATION		8	42 %	.7
.9 UNPROVEN			0 %	

DESIRED COURSE OF ACTION



N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	4		55 %	SHORT
MEDIUM		3	36 %	
LONG		1	9 %	
UNDESIRABLE			0 %	

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	2.7	75	74.6	1 - 4 YRS.
12	MOST LIKELY	3.9	78	77.7	3 1/2 - 7 1/2 YRS.
12	NOT LATER THAN	5.2	80	80.1	5 1/2 - 11 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	1.9	2 M	3.10 M	2.08 - 4.12
11	UPPER LIMIT	3.9	10 M	7.47 M	5.35 - 9.59

DOT ASSESSMENT RESULTS

EVENT: ID06 Manned spherical structural hulls 7 ft in diameter, fabricated from steel. Yield strength of 210 ksi; (W/D of 0.69); 99.9% reliability...same as ID05.

SYSTEM CRITICALITY

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL			17 %	
DESIRABLE	8		58 %	DESIRABLE
UNNECESSARY		8	25 %	

DEGREE OF RISK

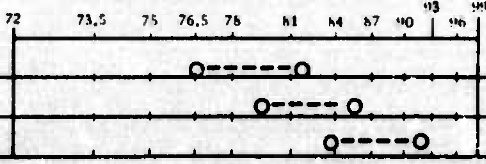
N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE		8	8 %	
.4 EXPERIMENTAL	8		0 %	
.7 SIMULATION		8	50 %	.7
.9 UNPROVEN	8		42 %	

DESIRED COURSE OF ACTION

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		8	8 %	
MEDIUM	25		17 %	
LONG		8	50 %	LONG
UNDESIRABLE		9	25 %	

PROBABLE TIMING

CALENDAR YEARS
(90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	4.7	80	78.9	4 1/2 - 9 1/2 YRS.
12	MOST LIKELY	5.8	85	83.3	8 1/2 - 14 1/2 YRS
12	NOT LATER THAN	7.4	90	87.7	12 - 19 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	9.7	5,20 M	12.41M	7.13 - 17.69
11	UPPER LIMIT	22.3	40 M	31.24M	19.07 - 43.40

DOT ASSESSMENT RESULTS

EVENT: ID07 Welding methods for HY 170-210 steels using an automated gas metal-arc (GMA) process rather than the gas tungsten-arc (GTA) process.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL			40 %	
DESIRABLE			50 %	DESIRABLE
UNNECESSARY			10 %	

DEGREE OF RISK

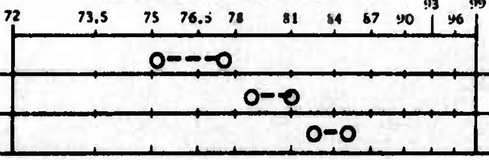
N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE	20		0 %	
.4 EXPERIMENTAL		26	56 %	.4
.7 SIMULATION		4	44 %	
.9 UNPROVEN	10		0 %	

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		10	20 %	
MEDIUM	10		60 %	MEDIUM
LONG			10 %	
UNDESIRABLE			10 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	2.1	75,76	76.6	3 1/2 - 6 YRS.
10	MOST LIKELY	2.0	80	79.9	6 1/2 - 9 YRS.
10	NOT LATER THAN	2.6	85	84.3	11 - 14 YRS.

ESTIMATED COSTS TO ACHIEVE

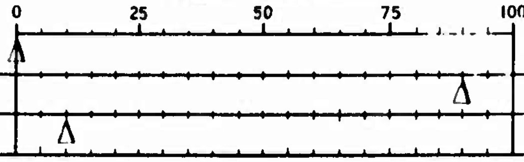
N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	.8	1 M	1.30 M	.80 - 1.80
9	UPPER LIMIT	3.3	2 M	4.39 M	2.37 - 6.41

DOT ASSESSMENT RESULTS

EVENT: ID08 Welding methods for HY 170-210 steels and Titanium using the electron beam process "out of vacuum" or with the welder and vacuum chamber moving along the joint.

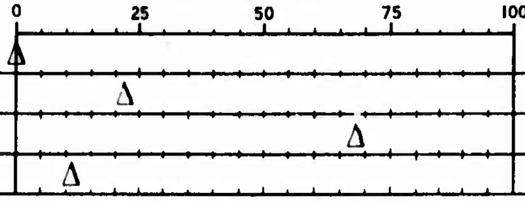
SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	10		0 %	
DESIRABLE		10	90 %	DESIRABLE
UNNECESSARY			10 %	



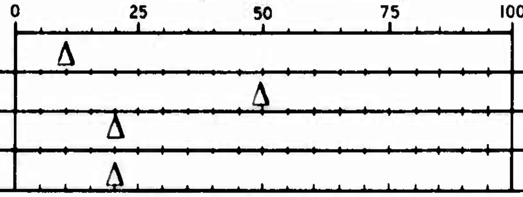
DEGREE OF RISK

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL		12	22 %	
.7 SIMULATION	13		67 %	.7
.9 UNPROVEN		1	11 %	



DESIRED COURSE OF ACTION

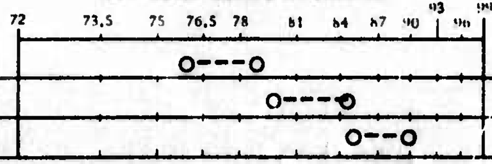
N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		10	10 %	
MEDIUM	20		50 %	MEDIUM
LONG		10	20 %	
UNDESIRABLE			20 %	



PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	2.3	75,80	77.3	4 - 6 1/2 YRS.
10	MOST LIKELY	3.8	80,85	82.2	8 - 12 1/2 YRS.
10	NOT LATER THAN	4.0	90	87.6	13 1/2 - 18 YRS.



ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	2.8	2 M	2.28 M	.55 - 4.01
9	UPPER LIMIT	8.4	2,4 M	7.44 M	2.21 - 12.68

DOT ASSESSMENT RESULTS

EVENT: ID09

Manned spherical structural hulls 7 ft in diameter, fabricated from "Transformation-Induced-Plasticity" (TRIP) steel. Yield strength of 250 ksi; (W/D of 0.58), with a ductility of at least 30%; 99.9% reliability at a 95% lower level of confidence.

SYSTEM CRITICALITY

N- 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL			Δ	0 %	
DESIRABLE			Δ	40 %	
UNNECESSARY			Δ	60 %	UNNECESSARY

DEGREE OF RISK

N- 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL			Δ	0 %	
.7 SIMULATION			Δ	0 %	
.9 UNPROVEN			Δ	100 %	.9

DESIRED COURSE OF ACTION

N- 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL			Δ	0 %	
MEDIUM			Δ	10 %	
LONG	14		Δ	30 %	
UNDESIRABLE		14	Δ	60 %	UNDESIRABLE

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	o----o	6,2	85	85.2	9 1/2 - 17 YRS.
10	MOST LIKELY	o----o	9.5	90	92.7	15 - 26 YRS.
9	NOT LATER THAN	o----o 2004	11.3	None	97.9	19 - 33 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	29.0	20 M	31.72M	13.74 - 49.70
8	UPPER LIMIT	57.9	100 M	78.25M	39.44 - 117.06

IE Sub-Technology: Buoyancy Materials

Objective: To develop buoyancy materials capable of operating down to 20,000-ft depths for at least 2,000 cycles and for periods of at least 2 years, with water absorption of less than 1% by weight at a surface-to-volume ratio of 1 inch $^{-1}$.

Events IE01 - IE03 address this objective.

DOT ASSESSMENT RESULTS

EVENT: IE01 Syntactic foam with a density of 32 lb/ft^3 (Binary packing).

SYSTEM CRITICALITY

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	6		64 %	ESSENTIAL
DESIRABLE		6	36 %	
UNNECESSARY			0 %	

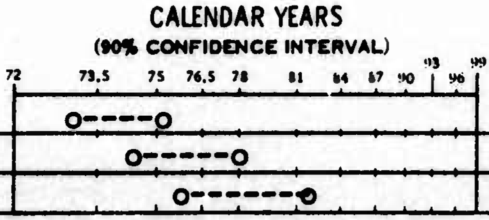
DEGREE OF RISK

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE	4		36 %	
.4 EXPERIMENTAL		5	55 %	.4
.7 SIMULATION	1		9 %	
.9 UNPROVEN			0 %	

DESIRED COURSE OF ACTION

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		12	82 %	SHORT
MEDIUM	12		18 %	
LONG			0 %	
UNDESIRABLE			0 %	

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	1.9	73,74	74.1	1 - 3 YRS.
11	MOST LIKELY	3.3	74	76.2	2 1/2 - 6 YRS.
11	NOT LATER THAN	5.6	75	78.9	4 - 10 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	.3	.1 M	.29 M	.11 - .48
11	UPPER LIMIT	1.5	.2,.5 M	1.21 M	.42-2.02

DOT ASSESSMENT RESULTS

EVENT: IE02 Syntactic foam with a density of 26 lb/ft^3 (Tertiary or higher degrees of packing).

SYSTEM CRITICALITY

	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
N= 11	LOSS	GAIN	0 25 50 75 100		
ESSENTIAL	11			9 %	
DESIRABLE		11		91 %	DESIRABLE
UNNECESSARY				0 %	

DEGREE OF RISK

	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
N= 11	LOSS	GAIN	0 25 50 75 100		
.1 PROTOTYPE				0 %	
.4 EXPERIMENTAL	12			18 %	
.7 SIMULATION		4		64 %	.7
.9 UNPROVEN		8		18 %	

DESIRED COURSE OF ACTION

	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
N= 10	LOSS	GAIN	0 25 50 75 100		
SHORT RANGE GOAL	10			0 %	
MEDIUM				90 %	MEDIUM
LONG		10		10 %	
UNDESIRABLE				0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST		3.1	74.75	75.9	2 - 5 1/2 YRS.
11	MOST LIKELY		4.4	75	78.5	4 - 9 YRS.
11	NOT LATER THAN		6.6	77	82.3	6 1/2 - 14 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	.8	.2 M	.85 M	.38 - 1.31
11	UPPER LIMIT	1.9	5 M	2.35 M	1.31 - 3.38

DOT ASSESSMENT RESULTS

EVENT: IE03

Active flotation with a system weight/displacement ratio of 0.3. Gas generation which automatically maintains an internal pressure in a thin-walled container at the ambient external pressure.

SYSTEM CRITICALITY

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	10		0 %	
DESIRABLE		6	36 %	
UNNECESSARY		4	64 %	UNNECESSARY

DEGREE OF RISK

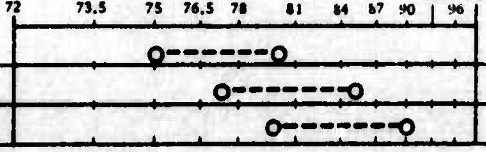
N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL			0 %	
.7 SIMULATION	2.5		60 %	.7
.9 UNPROVEN		2.5	40 %	

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		10	10 %	
MEDIUM	2		20 %	
LONG		7	40 %	LONG
UNDESIRABLE	15		30 %	

PROBABLE TIMING

CALENDAR YEARS
(90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	4.4	75	77.9	3 - 8 1/2 YRS.
9	MOST LIKELY	5.5	77	81	5 1/2 - 12 1/2 YRS.
8	NOT LATER THAN	6.7	80	84.6	8 - 17 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	2.9	1 M	2.90 M	1.12 - 4.68
8	UPPER LIMIT	15.1	5 M	10.90 M	.77 - 21.03

IF Sub-Technology: Miscellaneous Materials

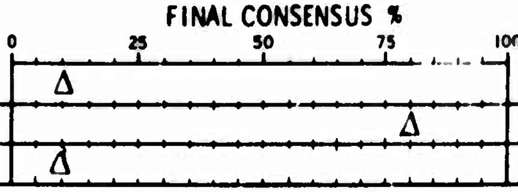
Objective: To develop miscellaneous materials capable of operating down to 20,000-ft depths for a determined period of time.

Events IF01 - IF06 address this objective.

DOT ASSESSMENT RESULTS

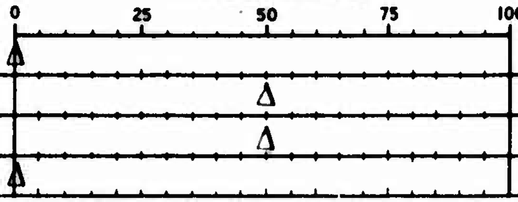
EVENT:	IF01	Manned cylindrical structures, 20 ft in diameter, fabricated from steel, capable of fixed operation at a depth of 8,000 ft for at least 2 years. 99.9% reliability at a 95% lower level of confidence.

SYSTEM CRITICALITY



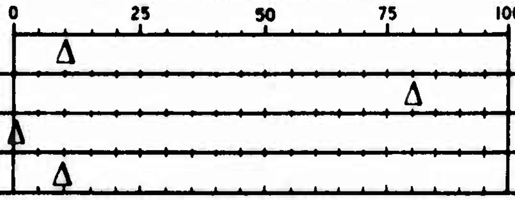
N= 10	PERCENTAGE LOSS	GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	12		10 %	
DESIRABLE		2	80 %	DESIRABLE
UNNECESSARY		10	10 %	

DEGREE OF RISK



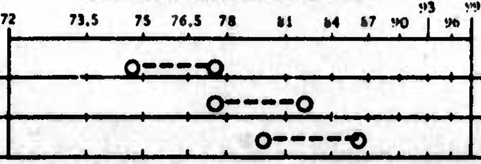
N= 10	PERCENTAGE LOSS	GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE	11		0 %	
.4 EXPERIMENTAL	6		50 %	
.7 SIMULATION		17	50 %	.7
.9 UNPROVEN			0 %	

DESIRED COURSE OF ACTION



N= 10	PERCENTAGE LOSS	GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	23		10 %	
MEDIUM		13	80 %	MEDIUM
LONG			0 %	
UNDESIRABLE		10	10 %	

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	2.1	75	76	3 - 5 YRS.
10	MOST LIKELY	3.7	77	79.6	5 1/2 - 10 YRS.
10	NOT LATER THAN	5.8	80	83.3	8 - 14 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	17.1	20 M	18.73M	8.82 - 28.64
10	UPPER LIMIT	83.3	20,80M	69.06M	20.77 - 117.35

DOT ASSESSMENT RESULTS

EVENT: IF02 Seal and gasket materials for use on large locks, capable of 2,000 cyclic operations at a depth of 8,000 ft for a period of at least 2 years.

SYSTEM CRITICALITY

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL			Δ	67 %	ESSENTIAL
DESIRABLE			Δ	33 %	
UNNECESSARY			Δ	0 %	

DEGREE OF RISK

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE	11		Δ	0 %	
.4 EXPERIMENTAL	11		Δ	44 %	
.7 SIMULATION		44	Δ	56 %	.7
.9 UNPROVEN	22		Δ	0 %	

DESIRED COURSE OF ACTION

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL			Δ	11 %	
MEDIUM			Δ	89 %	MEDIUM
LONG			Δ	0 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	o----o	2.1	75	76.1	3 - 5 1/2 YRS.
9	MOST LIKELY	o-----o	3.4	77	79.6	5 1/2 - 9 1/2 YRS
9	NOT LATER THAN	o-----o	5.4	90	83.4	8 - 15 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	.4	.5 M	.77 M	.46 - 1.07
9	UPPER LIMIT	2.8	1 M	2.53 M	.82 - 4.25

DOT ASSESSMENT RESULTS

EVENT: IF03 Protective coatings for metals which will virtually eliminate biological or corrosive damage during continuous exposure for 2 years at a depth of 8,000 ft.

SYSTEM CRITICALITY

N 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL	4.5		Δ	40 %	
DESIRABLE		5.5	Δ	50 %	DESIRABLE
UNNECESSARY	1		Δ	10 %	

DEGREE OF RISK

N 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE	2		Δ	20 %	
.4 EXPERIMENTAL		15	Δ	60 %	.4
.7 SIMULATION	2		Δ	20 %	
.9 UNPROVEN	11		Δ	0 %	

DESIRED COURSE OF ACTION

N 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL		6	Δ	50 %	SHORT
MEDIUM	6		Δ	50 %	
LONG			Δ	0 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	o---o	2.1	74	74.6	1 1/2 - 4 YRS.
10	MOST LIKELY	o-----o	3.5	76	76.8	3 - 7 YRS.
10	NOT LATER THAN	o-----o	5.1	78	79.4	4 1/2 - 10 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	.3	.1,.2 M	.28 M	.11 - .44
9	UPPER LIMIT	1.4	.5 M	1.29 M	.42 - 2.15

DOT ASSESSMENT RESULTS

EVENT: IF04

Protective coatings for viewports which will prevent fouling (no discernible decrease in visibility) for periods of 30 days in any ocean area.

SYSTEM CRITICALITY

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL	11		Δ	78 %	ESSENTIAL
DESIRABLE		11	Δ	22 %	
UNNECESSARY			Δ	0 %	

DEGREE OF RISK

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE	22		Δ	11 %	
.4 EXPERIMENTAL		22	Δ	67 %	.4
.7 SIMULATION			Δ	22 %	
.9 UNPROVEN			Δ	0 %	

DESIRED COURSE OF ACTION

N= 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL		9.5	Δ	87.5%	SHORT
MEDIUM	9.5		Δ	12.5 %	
LONG			Δ	0 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	o------o	2.3	73	74.2	1 - 3 1/2 YRS.
9	MOST LIKELY	o--------o	3.8	74	76.1	2 - 6 1/2 YRS.
9	NOT LATER THAN	o--------o	5.3	75	78.3	3 - 9 1/2 YRS.

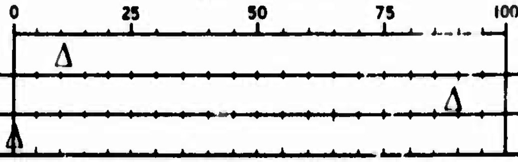
ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
8	LOWER LIMIT	.1	.2 M	.26 M	.18 - .33
8	UPPER LIMIT	.2	.5 M	.54 M	.40 - .68

DOT ASSESSMENT RESULTS

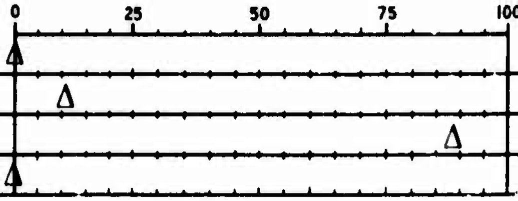
EVENT: IF05 **Protective coatings for viewports which will prevent fouling (no discernible decrease in visibility) for period of 2 years in any ocean area.**

SYSTEM CRITICALITY



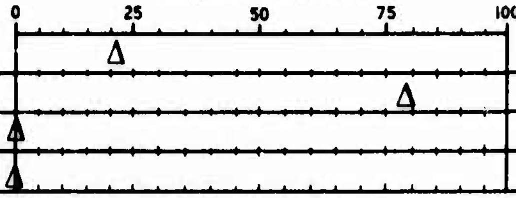
N· 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	11		11 %	
DESIRABLE		11	89 %	DESIRABLE
UNNECESSARY			0 %	

DEGREE OF RISK



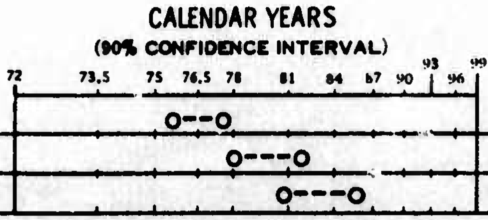
N· 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL	11		11 %	
.7 SIMULATION		22	89 %	.7
.9 UNPROVEN	11		0 %	

DESIRED COURSE OF ACTION



N· 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			22 %	
MEDIUM		22	78 %	MEDIUM
LONG	22		0 %	
UNDESIRABLE			0 %	

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	1.8	77	76.8	3 1/2 - 6 YRS.
9	MOST LIKELY	2.7	80	79.7	6 - 9 1/2 YRS.
9	NOT LATER THAN	4.4	83,90	83.6	9 - 14 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	.1	.5 M	.42 M	.33 - .51
9	UPPER LIMIT	.5	1 M	1.07 M	.78 - 1.35

DOT ASSESSMENT RESULTS

EVENT: IF06 Acrylic hemispherical viewport 24 inches inside diameter suitable for use in manned structural hulls for fixed operation at a depth of 8,000 ft for periods of 2 years. 99.9% reliability at a 95% level of confidence.

SYSTEM CRITICALITY

N- 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	4.5		33 %	
DESIRABLE		4.5	67 %	DESIRABLE
UNNECESSARY			0 %	

DEGREE OF RISK

N- 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE	1.5		11 %	
.4 EXPERIMENTAL	3		22 %	
.7 SIMULATION		4.5	67 %	.7
.9 UNPROVEN			0 %	

DESIRED COURSE OF ACTION

N- 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	15.5		22 %	
MEDIUM		15.5	78 %	MEDIUM
LONG			0 %	
UNDESIRABLE			0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL)	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	o-----o	2.0	75,76	75.8	2 1/2 - 5 YRS.
9	MOST LIKELY	o----o	3.2	80	79.3	5 1/2 - 9 1/2 YRS.
9	NOT LATER THAN	o-----o	5.1	85	83.4	8 1/2 - 14 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	.5	.5 M	.63 M	.32 - .95
9	UPPER LIMIT	1.1	1 M	1.59 M	.92 - 2.26

IG Sub-Technology: Structures

Objective: To develop new and better methods for evaluating various concepts of pressure hulls constructed from available and projected material relative to performance criteria, fabricability, and configuration analysis verification.

Events IG01 - IG03 address this objective.

DOT ASSESSMENT RESULTS

EVENT: IG01

Analytical structural calculations which accurately predict static and dynamic stresses and strains for complex structual hull shapes, appendages and interfaces, including toroids, ring-stiffened hulls, sandwich materials, penetrations, hull intersections, and thick-walled hulls.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL		2	80 %	ESSENTIAL
DESIRABLE	2		20 %	
UNNECESSARY			0 %	

DEGREE OF RISK

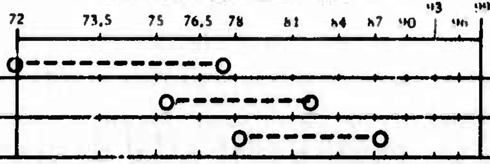
N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE		15	60 %	.1
.4 EXPERIMENTAL	1		10 %	
.7 SIMULATION	13		20 %	
.9 UNPROVEN	1		10 %	

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		1	90 %	SHORT
MEDIUM			0 %	
LONG	1		10 %	
UNDESIRABLE			0 %	

PROBABLE TIMING

CALENDAR YEARS
(90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	4.9	72,74	74.6	0 - 5 1/2 YRS.
10	MOST LIKELY	4.9	76	78.2	3 1/2 - 9 YRS.
10	NOT LATER THAN	8.2	74	82.8	6 - 15 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	14.4	1 M	7.09 M	0 - 15.47
10	UPPER LIMIT	58.3	5 M	25.68 M	0 - 59.46

DOT ASSESSMENT RESULTS

EVENT: IG02

Unmanned cylindrical internal hydrostatic pressure vessels 20 ft in diameter, capable of 30,000 psi static pressure, and 10,000 psi cyclic pressure (5 million cycles) with simultaneous thermal cycling for 90°F to 28°F. The design is fail-safe such that pressure loss occurs before a catastrophic failure.

SYSTEM CRITICALITY

N= 9	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
ESSENTIAL	1.5		Δ	11 %	
DESIRABLE		1.5	Δ	89 %	DESIRABLE
UNNECESSARY			Δ	0 %	

DEGREE OF RISK

N= 9	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL	17		Δ	33 %	
.7 SIMULATION		6	Δ	56 %	.7
.9 UNPROVEN		11	Δ	11 %	

DESIRED COURSE OF ACTION

N= 8	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
SHORT RANGE GOAL		12.5	Δ	12.5 %	
MEDIUM		12.5	Δ	75 %	MEDIUM
LONG	25		Δ	12.5 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	o-------o	5.4	77	80.3	5 - 11 1/2 YRS.
9	MOST LIKELY	o--------o	7.5	80	84.2	7 1/2 - 17 YRS.
9	NOT LATER THAN	o-------o	9.4	85	89.4	11 1/2 - 23 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	30.1	20 M	25.13 M	6.49 - 43.78
9	UPPER LIMIT	147.1	80 M	95.11 M	3.92 - 186.3

DOT ASSESSMENT RESULTS

EVENT: IG03 Design of mating systems and appendages to withstand the dynamic loads resulting from joining structural modules and temporarily mating submersibles with other structures.

SYSTEM CRITICALITY

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL			Δ	78 %	ESSENTIAL
DESIRABLE			Δ	22 %	
UNNECESSARY			Δ	0 %	

DEGREE OF RISK

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE		11	Δ	45 %	.1
.4 EXPERIMENTAL	11		Δ	22 %	
.7 SIMULATION			Δ	33 %	
.9 UNPROVEN			Δ	0 %	

DESIRED COURSE OF ACTION

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL		19.5	Δ	44.5%	SHORT
MEDIUM	30.5		Δ	44.5%	
LONG		11	Δ	11 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	o-------------o	5.8	72	76.2	1/2 - 8 YRS.
9	MOST LIKELY	o---------o	6.2	77	79.8	4 - 11 1/2 YRS
9	NOT LATER THAN	o-------o	7.5	None	83.6	7 - 16 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	15.4	.5,.6 M	6.59 M	0 - 16.14
9	UPPER LIMIT	30.6	1 M	13.48M	0 - 32.48

APPENDIX B

TECHNOLOGY AREA II. MACHINERY AND EQUIPMENT

SUB-TECHNOLOGY AREAS:

A. Remote Unmanned Work Systems
B. Ballast Systems
C. Hydraulic Systems

IIA Sub-Technology: Remote Unmanned Work System

Objective: To advance the technologies necessary to design and operate work systems at depths of 20,000 ft, which would be capable of accomplishing the following:

- O Provide highly versatile manipulators to perform a variety of manual tasks such as lifting and moving objects, or using mechanical or power tools. The manipulators must be capagle of performing both delicate work and work requiring great force, while at the same time achieving a high degree of articulation and control including tactile feedback.

Events IIA01 - IIA08 address this objective.

DOT ASSESSMENT RESULTS

EVENT: IIA01

A remote controlled (via cabled signals) electromechanical, (eight degrees of freedom) manipulator arm work system with position feedback on all degrees of freedom and force feedback on four degrees of freedom (i.e., three translations and grip) capable of performing mechanical tasks with the aid of a holding arm ar 20,000-ft ocean depths. The system has a 48-inch reach, can lift 25 pounds, has a grip strength of 100 pounds, can apply a wrist torque of 20 pound feet, has a wrist extension of 4 inches, and weighs less than 100 pounds.

SYSTEM CRITICALITY

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL			0 %	
DESIRABLE		4	83 %	DESIRABLE
UNNECESSARY	4		17 %	

DEGREE OF RISK

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL		11	25 %	
.7 SIMULATION	5		67 %	.7
.9 UNPROVEN	6		8 %	

DESIRED COURSE OF ACTION

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		8	8 %	
MEDIUM	10		67 %	MEDIUM
LONG			8 %	
UNDESIRABLE		2	17 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL)	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	o-o	.6	74	74.6	2 1/2 - 3 YRS.
12	MOST LIKELY	o-o	.9	76	76.6	4 - 5 YRS.
12	NOT LATER THAN	o-o	1.4	80	78.9	6 - 8 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	.4	1,1.5M	1.18 M	.94 - 1.42
11	UPPER LIMIT	.8	3 M	2.86 M	2.43 - 3.30

DOT ASSESSMENT RESULTS

EVENT: IIA02 A remote controlled (via cabled signals), hydraulic, eight degrees of freedom manipulator arm ... same as IIA01 ...

SYSTEM CRITICALITY

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)	CONCLUSION
ESSENTIAL			0 %	
DESIRABLE		12	83 %	DESIRABLE
UNNECESSARY	12		17 %	

DEGREE OF RISK

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL		1	8 %	
.7 SIMULATION		5	84 %	.7
.9 UNPROVEN	6		8 %	

DESIRED COURSE OF ACTION

N=12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)	CONCLUSION
SHORT RANGE GOAL			0 %	
MEDIUM		4	66 %	MEDIUM
LONG		2	17 %	
UNDESIRABLE	6		17 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	o-o	.8	74,75	74.5	2 - 3 YRS.
11	MOST LIKELY	o-o	.9	77	76.8	3 1/2 - 4 1/2 YRS.
11	NOT LATER THAN	o-o	1.4	80	79.1	5 1/2 - 8 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	.3	1 M	1.18 M	.97 - 1.39
11	UPPER LIMIT	1.4	3 M	3.29 M	2.51 - 4.06

DOT ASSESSMENT RESULTS

EVENT: IIA03

A remote controlled (via cabled signals) hydraulic, eight degrees of freedom manipulator arm work system with position feedback for all degrees of freedom and force feedback for four degrees of freedom (i.e., three translations and grip) capable of mechanical tasks with aid of holding arm at 20,000 ft. The system has a 7-ft reach, lifts 150 pounds, has a grip strength of 500 pounds, a wrist torque of 30 pounds/feet, a wrist extension of 6 inches, and no weight limitation other than minimize.

SYSTEM CRITICALITY

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL		14	Δ	50 %	ESSENTIAL
DESIRABLE	22		Δ	42 %	
UNNECESSARY		8	Δ	8 %	

DEGREE OF RISK

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE		8	Δ	8 %	
.4 EXPERIMENTAL	14		Δ	0 %	
.7 SIMULATION	2		Δ	84 %	.7
.9 UNPROVEN		8	Δ	8 %	

DESIRED COURSE OF ACTION

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL		4	Δ	58 %	SHORT
MEDIUM		4	Δ	34 %	
LONG			Δ	8 %	
UNDESIRABLE	8		Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	o--o	.7	75	75.0	2 1/2-3 1/2 YRS
11	MOST LIKELY	o-o	1.0	76	77.1	4 1/2-5 1/2 YRS
11	NOT LATER THAN	o---o	1.8	80	78.9	6 - 8 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	.6	1.5 M	1.50 M	1.16 - 1.85
11	UPPER LIMIT	.8	3 M	3.23 M	2.76-3.70

DOT ASSESSMENT RESULTS

EVENT: IIA04 A remote controlled (via cabled signals), electromechanical, eight degrees of freedom manipulator arm ... same as IIA03 ...

SYSTEM CRITICALITY

N- 12	PERCENTAGE LOSS	 GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL			Δ	8 %	
DESIRABLE	4		Δ	58 %	DESIRABLE
UNNECESSARY		4	Δ	34 %	

DEGREE OF RISK

N- 12	PERCENTAGE LOSS	 GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL	8		Δ	0 %	
.7 SIMULATION	1		Δ	83 %	.7
.9 UNPROVEN		9	Δ	17 %	

DESIRED COURSE OF ACTION

N-12	PERCENTAGE LOSS	 GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL		8	Δ	17 %	
MEDIUM	4		Δ	33 %	MEDIUM
LONG	2		Δ	25 %	
UNDESIRABLE	2		Δ	25 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	o-o	.8	75	75.1	2 1/2-3 1/2 YRS.
12	MOST LIKELY	oo	1.2	77,78	77.25	4 1/2-6 YRS.
12	NOT LATER THAN	oo	1.4	80	79.4	6 1/2-8 YRS.

ESTIMATED COSTS TO ACHIEVE

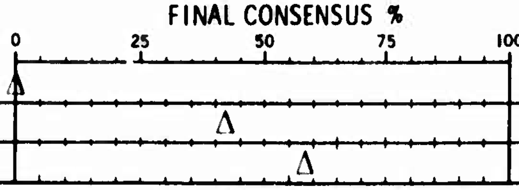
N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	.4	1.5,2M	1.57 M	1.32 - 1.82
11	UPPER LIMIT	.6	3 M	3.50 M	3.15 - 3.85

DOT ASSESSMENT RESULTS

EVENT: IIA05

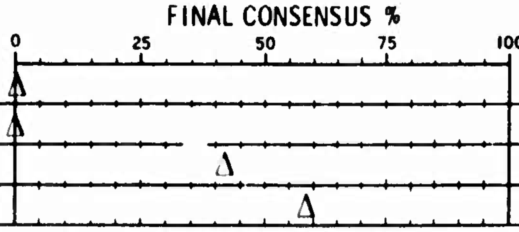
A remote controlled (via cabled signals), electromechanical, eight degrees of freedom manipulator arm work system with position feedback on all degrees of freedom and force feedback on four degrees of freedom (i.e., three translations and grip) capable of performing mechanical tasks with the aid of a holding arm at 20,000-ft ocean depths. The system has a 10-ft reach, can lift 500 pounds, has a grip strength of 1,000 pounds, can apply a wrist torque of 60 pound/feet, has a wrist extension of 8 inches, and weighs less than 300 pounds.

SYSTEM CRITICALITY



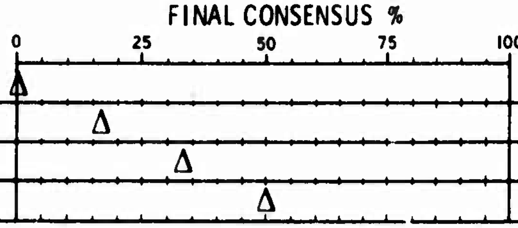
N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL			0 %	
DESIRABLE	8		42 %	
UNNECESSARY		8	58 %	UNNECESSARY

DEGREE OF RISK



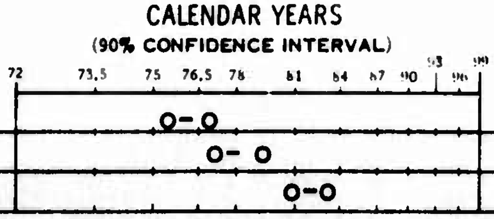
N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL	14		0 %	
.7 SIMULATION		21	42 %	
.9 UNPROVEN	7		58 %	.9

DESIRED COURSE OF ACTION



N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			0 %	
MEDIUM		3	17 %	
LONG	10		33 %	
UNDESIRABLE		7	50 %	UNDESIRABLE

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	.8	76	76.2	3 1/2-4 1/2 YRS.
11	MOST LIKELY	1.8	80	78.3	5 1/2-7 YRS.
11	NOT LATER THAN	2.3	85	82.3	9- 11/1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	.9	3 M	2.45 M	1.91 - 2.99
10	UPPER LIMIT	1.1	4 M	4.85 M	4.21 - 5.49

DOT ASSESSMENT RESULTS

EVENT: IIA06 A remote controlled (via cabled signals), hydraulic, eight degrees of freedom manipulator arm ... same as IIA05 ...

SYSTEM CRITICALITY

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL	7		Δ	0 %	
DESIRABLE		3	Δ	75 %	DESIRABLE
UNNECESSARY		4	Δ	25 %	

DEGREE OF RISK

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL	14		Δ	0 %	
.7 SIMULATION		4	Δ	33 %	
.9 UNPROVEN		10	Δ	67 %	.9

DESIRED COURSE OF ACTION

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL			Δ	0 %	
MEDIUM	9		Δ	27 %	
LONG		+5	Δ	55 %	LONG
UNDESIRABLE		+4	Δ	18 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 67 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	o-o	.9	76	76.0	3 1/2 - 4 1/2 YRS.
10	MOST LIKELY	o -o	1.2	78	78.4	5 1/2 - 7 YRS.
10	NOT LATER THAN	o- o	2.3	80	82.0	8 1/2 -11 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	.9	3 M	2.60 M	2.08 - 3.12
10	UPPER LIMIT	1.0	4 M	5.10 M	4.50 - 5.70

DOT ASSESSMENT RESULTS

EVENT: IIA07 An attachable (e.g., clamps, suction cups, adhesives, etc) lifting device, using chemical gas generation for buoyancy capable of lifting a 250-pound object from the ocean floor at a depth of 20,000 ft to the surface.

SYSTEM CRITICALITY

N=12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	7		50 %	ESSENTIAL
DESIRABLE		6	42 %	
UNNECESSARY		1	8 %	

DEGREE OF RISK

N=12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE	14		0 %	
.4 EXPERIMENTAL		6	42 %	
.7 SIMULATION			42 %	.7
.9 UNPROVEN		8	16 %	

DESIRED COURSE OF ACTION

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		20	84 %	SHORT
MEDIUM	29		0 %	
LONG		8	8 %	
UNDESIRABLE		1	8 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	.9	74	74.1	1 1/2 - 2 1/2 YRS.
11	MOST LIKELY	2.0	76	76.2	3 - 5 1/2 YRS.
11	NOT LATER THAN	3.0	78,80	79.4	5 1/2 - 9 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	1.3	.5 M	.95 M	.24 - 1.67
11	UPPER LIMIT	5.4	1 M	2.96 M	.01 - 5.92

DOT ASSESSMENT RESULTS

EVENT: IIA08 An attachable (e.g., clamps, suction cups, adhesives, etc) lifting device, using pressure sphere dewatering for buoyancy capable of lifting... same as IIA07 ...

SYSTEM CRITICALITY

N=12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	6		8 %	
DESIRABLE		20	92 %	DESIRABLE
UNNECESSARY	14		0 %	

DEGREE OF RISK

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE	7		0 %	
.4 EXPERIMENTAL	3		33 %	
.7 SIMULATION		9	59 %	.7
.9 UNPROVEN		1	8 %	

DESIRED COURSE OF ACTION

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		11	33 %	
MEDIUM	5		59 %	MEDIUM
LONG		1	8 %	
UNDESIRABLE	7		0 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	.8	74	74.1	1 1/2-2 1/2 YRS.
12	MOST LIKELY	1.9	75	75.8	3 - 5 YRS.
12	NOT LATER THAN	3.1	78	78.6	5 - 8 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	1.3	.5 M	.84 M	.11 - 1.56
11	UPPER LIMIT	5.5	1 M	2.72 M	0 - 5.71

IIB Sub-Technology: Ballast Systems

Objective: To develop a lightweight, relatively compact (120 lbs/ft^3), highly reliable, efficient ballasting system that has a low-power requirement and can operate at 20,000-ft depths (near silty bottoms, if required). The systems components must be based upon 500 hours unattended and 2,000 hours intermittant operations.

Events IIB01 - IIB10 address this objective.

DOT ASSESSMENT RESULTS

EVENT: IIB01 A seawater ballast positive displacement pump capable of pumping against the seawater pressure for 2,000 hours intermittant at 20,000-ft ocean depths at a 2.5 gpm rate.

SYSTEM CRITICALITY

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL		5	Δ	82 %	ESSENTIAL
DESIRABLE	5		Δ	18 %	
UNNECESSARY			Δ	0 %	

DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE	3		Δ	20 %	
.4 EXPERIMENTAL	3		Δ	20 %	
.7 SIMULATION		6	Δ	60 %	.7
.9 UNPROVEN			Δ	0 %	

DESIRED COURSE OF ACTION

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL	3		Δ	82 %	SHORT
MEDIUM		3	Δ	18 %	
LONG			Δ	0 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	OO	.8	74	74.1	1 1/2-2 1/2 YRS.
10	MOST LIKELY	O-O	1.0	75	75.8	3 - 4 1/2 YRS.
10	NOT LATER THAN	O--O	1.0	78	77.7	5 - 6 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	.4	.5 M	.625 M	.36 - .89
10	UPPER LIMIT	.8	1 M	1.57 M	1.09 - 2.05

DOT ASSESSMENT RESULTS

EVENT: IIB02 A ballast fluid (oil) positive displacement pump capable of pumping ...same as IIB01 ...

SYSTEM CRITICALITY

N=11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL	6		Δ	9 %	
DESIRABLE		5	Δ	82 %	DESIRABLE
UNNECESSARY		1	Δ	9 %	

DEGREE OF RISK

N=10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE		2	Δ	10 %	
.4 EXPERIMENTAL		12	Δ	50 %	.4
.7 SIMULATION	13		Δ	10 %	
.9 UNPROVEN	1		Δ	30 %	

DESIRED COURSE OF ACTION

N=11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL		6	Δ	73 %	SHORT
MEDIUM	7		Δ	18 %	
LONG			Δ	0 %	
UNDESIRABLE		1	Δ	9 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	o-o	.9	74	74.2	1 1/2-2 1/2 YRS.
10	MOST LIKELY	o -o	1.3	75	75.8	3 - 4 1/2 YRS
10	NOT LATER THAN	o--o	1.5	77,78	77.8	5 - 6 1/2 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	.3	.5 M	.65 M	.43 - .87
10	UPPER LIMIT	1.0	23 M	1.73 M	1.14 - 2.32

DOT ASSESSMENT RESULTS

EVENT: IIB03 A seawater ballast hydraulic system capable of transferring seawater against . . . same as IIB01 . . .

SYSTEM CRITICALITY

N- 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL		6	Δ	60 %	ESSENTIAL
DESIRABLE	6		Δ	40 %	
UNNECESSARY			Δ	0 %	

DEGREE OF RISK

N- 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE	4		Δ	11 %	
.4 EXPERIMENTAL		7	Δ	22 %	
.7 SIMULATION	3		Δ	67 %	.7
.9 UNPROVEN			Δ	0 %	

DESIRED COURSE OF ACTION

N-10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL	9		Δ	60 %	SHORT
MEDIUM		9	Δ	40 %	
LONG			Δ	0 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	OO	.6	74	74.3	2 - 2 1/2 YRS.
9	MOST LIKELY	O—O	.8	76	76.2	3 1/2 - 4 1/2RS
9	NOT LATER THAN	O-O	1.5	78	78.2	5 1/2 - 7 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	.3	.5 M	.81M	.60 - 1.01
8	UPPER LIMIT	.7	2,3 M	2.23M	1.77 - 2.68

DOT ASSESSMENT RESULTS

EVENT: IIB04 A ballast fluid (oil) hydraulic system capable of transferring fluid against . . . same as IIB01.

SYSTEM CRITICALITY

N= 10	PERCENTAGE		FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
	LOSS	GAIN			
ESSENTIAL	7		Δ	10 %	
DESIRABLE		12	Δ	70 %	DESIRABLE
UNNECESSARY	5		Δ	20 %	

DEGREE OF RISK

N= 9	PERCENTAGE		FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
	LOSS	GAIN			
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL	20		Δ	22 %	
.7 SIMULATION		12	Δ	45 %	.7
.9 UNPROVEN		8	Δ	33 %	

DESIRED COURSE OF ACTION

N= 9	PERCENTAGE		FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
	LOSS	GAIN			
SHORT RANGE GOAL	6		Δ	44 %	
MEDIUM		22	Δ	56 %	MEDIUM
LONG	8		Δ	0 %	
UNDESIRABLE	8		Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	oo	.6	74	74.3	2 - 2 1/2 YRS.
9	MOST LIKELY	o-o	.6	76	76.3	4 - 4 1/2 YRS.
9	NOT LATER THAN	o-o	1.3	78	78.4	5 1/2 - 7 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	.4	.5 M	.82 M	.53 - 1.11
9	UPPER LIMIT	1.1	2 M	2.08 M	1.39 - 2.77

DOT ASSESSMENT RESULTS

EVENT: IIB05 A hydraulically-operated, 2-inch seawater valve with a wet weight of less than 50 lbs, highly reliable, and capable of 500 operations of bubble tight shut-off at depths of 20,000 ft against differential pressures of 10,000 psi.

SYSTEM CRITICALITY

	PERCENTAGE		FINAL CONSENSUS %	
N= 11	LOSS	GAIN	0 25 50 75 100	CONCLUSION
ESSENTIAL	5		18 %	
DESIRABLE	7		55 %	DESIRABLE
UNNECESSARY		12	27 %	

DEGREE OF RISK

	PERCENTAGE		FINAL CONSENSUS %	
N= 10	LOSS	GAIN	0 25 50 75 100	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL	8		0 %	
.7 SIMULATION		2	40 %	
.9 UNPROVEN		6	60 %	.9

DESIRED COURSE OF ACTION

	PERCENTAGE		FINAL CONSENSUS %	
N= 10	LOSS	GAIN	0 25 50 75 100	CONCLUSION
SHORT RANGE GOAL	18		20 %	
MEDIUM		14	60 %	MEDIUM
LONG			0 %	
UNDESIRABLE		4	20 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

72 73.5 75 76.5 78 81 84 87 90 93 96 99

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	.5	74	74.1	2 - 2 1/2 YRS.
10	MOST LIKELY	1.0	76	76.0	3 1/2-4 1/2 YRS.
10	NOT LATER THAN	1.8	78	78.0	5 - 7 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	.1	.2 M	.25M	.16 - .34
9	UPPER LIMIT	.8	1 M	.99M	.48 - 1.50

DOT ASSESSMENT RESULTS

EVENT: IIB06 An electrically-operated, 2-inch seawater valve
... same as IIB05 ...

SYSTEM CRITICALITY

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL			Δ	0 %	
DESIRABLE	3		Δ	82 %	DESIRABLE
UNNECESSARY		3	Δ	18 %	

DEGREE OF RISK

N=10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL		2	Δ	10 %	
.7 SIMULATION		2	Δ	40 %	
.9 UNPROVEN	4		Δ	50 %	.9

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL			Δ	0 %	
MEDIUM		5	Δ	90 %	MEDIUM
LONG			Δ	0 %	
UNDESIRABLE	5		Δ	10 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	oo	.8	74	74.3	2 - 2 1/2 YRS.
10	MOST LIKELY	o--o	1.2	76	76.3	3 1/2 - 5 YRS.
10	NOT LATER THAN	o-o	2.0	78	78.5	5 1/2 - 7 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	.3	.2 M	.36M	.20 - .53
9	UPPER LIMIT	1.0	.3,1 M	1.16M	.53 - 1.78

DOT ASSESSMENT RESULTS

EVENT: IIB07 An hydraulically-operated, 2-inch gas valve
...same as IIB05...

SYSTEM CRITICALITY

N = 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %		CONCLUSION
ESSENTIAL		1	0 25 50 75 100	9 %	
DESIRABLE	14			55 %	DESIRABLE
UNNECESSARY		13		36 %	

DEGREE OF RISK

N = 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %		CONCLUSION
.1 PROTOTYPE			0 25 50 75 100	0 %	
.4 EXPERIMENTAL		2		10 %	
.7 SIMULATION		2		40 %	
.9 UNPROVEN	4			50 %	.9

DESIRED COURSE OF ACTION

N = 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %		CONCLUSION
SHORT RANGE GOAL		5	0 25 50 75 100	20 %	
MEDIUM	12			50 %	MEDIUM
LONG				0 %	
UNDESIRABLE		7		30 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	o---o	1.4	74	74.3	1 1/2 - 3 YRS.
9	MOST LIKELY	o----o	2.0	76	76.1	3 - 5 1/2 YRS.
9	NOT LATER THAN	o--o	2.8	78	78.11	4 1/2 - 8 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	.5	.1,.2M	.41 M	.06 - .77
9	UPPER LIMIT	1.7	1 M	1.24 M	.18 - 2.30

DOT ASSESSMENT RESULTS

EVENT: IIB08 An electrically-operated, 2-inch gas valve... same as IIB05.

SYSTEM CRITICALITY

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL			Δ	0 %	
DESIRABLE	22		Δ	54.5%	DESIRABLE
UNNECESSARY		22	Δ	45.5%	

DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL	5		Δ	10 %	
.7 SIMULATION		9	Δ	40 %	
.9 UNPROVEN	4		Δ	50 %	.9

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL			Δ	0 %	
MEDIUM	9		Δ	60 %	MEDIUM
LONG	8		Δ	0 %	
UNDESIRABLE		17	Δ	40 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	o-o	1.3	74	74.5	2 - 3 YRS.
9	MOST LIKELY	o--o	1.7	76	76.6	3 1/2-5 1/2 YRS.
9	NOT LATER THAN	o-- o	2.6	78	78.8	5 - 8 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	.9	.2,.5M	.57 M	.03 - 1.11
9	UPPER LIMIT	2.9	.2,1 M	1.79 M	.00 - 3.62

DOT ASSESSMENT RESULTS

EVENT: IIB09 An hydraulically-operated, 2-inch oil valve...same as IIB05.

SYSTEM CRITICALITY

N• 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL	6		Δ	9 %	
DESIRABLE		3	Δ	73 %	DESIRABLE
UNNECESSARY		3	Δ	18 %	

DEGREE OF RISK

N• 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL		5	Δ	20 %	
.7 SIMULATION		17	Δ	40 %	.7
.9 UNPROVEN	22		Δ	40 %	.9

DESIRED COURSE OF ACTION

N• 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL	1		Δ	30 %	
MEDIUM		6	Δ	60 %	MEDIUM
LONG			Δ	0 %	
UNDESIRABLE	5		Δ	10 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	o-o	.8	74	74.1	1 1/2-2 1/2 YRS.
10	MOST LIKELY	o--o	1.3	76	76	3 - 5 YRS.
10	NOT LATER THAN	o-o	2.0	78	77.9	5 - 7 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	.4	.1,.2M	.36 M	.1 - .62
9	UPPER LIMIT	1.7	.2,1 M	1.2 M	.13 - 2.27

DOT ASSESSMENT RESULTS

EVENT: IIB10 An electrically-operated, 2-inch oil valve...same as IIB05.

SYSTEM CRITICALITY

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL			0 %	
DESIRABLE	1		82 %	DESIRABLE
UNNECESSARY		1	18 %	

DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL		3	20 %	
.7 SIMULATION		15	40 %	.7
.9 UNPROVEN	18		40 %	

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			0 %	
MEDIUM		15	90 %	MEDIUM
LONG	8		0 %	
UNDESIRABLE	7		10 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	1.0	74	74.4	2 - 3 YRS.
10	MOST LIKELY	1.4	76	76.4	3 1/2 - 5 YRS.
10	NOT LATER THAN	2.0	78	78.5	5 1/2 - 7 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	.3	.2, .5M	.35 M	.18 - .52
9	UPPER LIMIT	.8	.2,1 M	.84 M	.34 - 1.35

IIC Sub-Technology: Hydraulic Systems

Objective: To advance the technologies necessary to have 20,000-ft seawater hydraulic systems for use in submersible and remote work systems.

Events IIC01 - IIC02 address this objective.

DOT ASSESSMENT RESULTS

EVENT: IIC01

A low-pressure (500 psi over ambient pressure) hydraulic system using seawater as the hydraulic fluid. The system is open-ended, and includes cylinders, rotary actuators, hydraulic motors, valves and pressure accumulators. It is undisturbed by fine silt contamination, and is operable for 1,000 hours to ocean depths down to 20,000 ft. Radiated noise of the system regardless of size or speed, should not exceed 30 db above .0002 microbars at a distance of 10 ft.

SYSTEM CRITICALITY

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	4		50 %	ESSENTIAL
DESIRABLE		11	42 %	
UNNECESSARY	7		8 %	

DEGREE OF RISK

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE		2	18 %	
.4 EXPERIMENTAL			0 %	
.7 SIMULATION		13	55 %	.7
.9 UNPROVEN	15		27 %	

DESIRED COURSE OF ACTION

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		13	46 %	SHORT
MEDIUM		2	27 %	
LONG	16		9 %	
UNDESIRABLE		1	18 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST		.6	74,75	74.7	2 1/2 - 3 YRS.
9	MOST LIKELY		.8	77	76.6	4 -5 YRS.
9	NOT LATER THAN		3.8	80	79.8	5 1/2 - 10 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	1.7	.6,2 M	2.02M	1.04 - 3.0
10	UPPER LIMIT	14.4	4 M	10.03M	1.68 - 18.38

DOT ASSESSMENT RESULTS

EVENT: IIC02 A high-pressure (2,000 psi over ambient pressure) hydraulic system... same as IIC01

SYSTEM CRITICALITY

N- 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	14		25 %	
DESIRABLE		12	58 %	DESIRABLE
UNNECESSARY		2	17 %	

DEGREE OF RISK

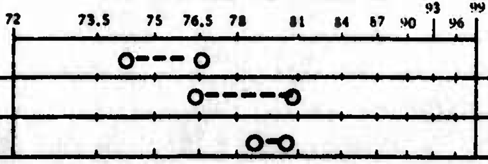
N- 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE		1	9 %	
.4 EXPERIMENTAL		1	9 %	
.7 SIMULATION	7		27 %	
.9 UNPROVEN		5	55 %	.9

DESIRED COURSE OF ACTION

N- 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		1	9 %	
MEDIUM		4	46 %	MEDIUM
LONG	15		27 %	
UNDESIRABLE		10	18 %	

PROBABLE TIMING

CALENDAR YEARS
(90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	1.7	75	75.5	2 1/2 - 4 1/2 YRS.
10	MOST LIKELY	4.0	78	78.5	4 - 9 YRS.
9	NOT LATER THAN	1.8	80	79.6	6 1/2 - 8 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	2.4	5 M	3.2 M	1.82 - 4.58
10	UPPER LIMIT	22.7	3 M	15.44 M	2.31 - 28.57

APPENDIX C

TECHNOLOGY AREA III. SEAFLOOR CONSTRUCTION

SUB-TECHNOLOGY AREAS:

A. Construction by Divers
B. Site Selection and Preparation
C. On-Bottom Construction
D. In-Bottom Construction

IIIA Sub-Technology: Construction by Divers

Objective: To develop the techniques and hardware necessary for divers to conduct underwater construction for extended periods on the continental shelf (to 1,000 ft). The construction capability will include the following:

- O Site selection
- O Site preparation
- O Facility construction

Events IIIA01 - IIIA06 address this objective.

DOT ASSESSMENT RESULTS

EVENT: IIIA01

Hydraulic systems with attachable tool suits that will provide the conventional construction function, sawing, drilling, torqueing, hammering, holding, positioning, etc., utilizing conventional hydraulic fluids and are specifically designed for use by divers underwater to depths of 1,000 ft.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL			Δ	50 %	ESSENTIAL
DESIRABLE			Δ	50 %	DESIRABLE
UNNECESSARY			Δ	0 %	

DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE			Δ	40 %	.1
.4 EXPERIMENTAL			Δ	20 %	
.7 SIMULATION			Δ	40 %	.7
.9 UNPROVEN			Δ	0 %	

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL			Δ	90 %	SHORT
MEDIUM			Δ	10 %	
LONG			Δ	0 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	o—o	.9	74	73.9	1½ - 2½ YRS.
10	MOST LIKELY	o—o	1.2	75	75.8	3 - 4½ YRS.
10	NOT LATER THAN	o—o	2.0	80	78.7	5½ - 8 YRS.

ESTIMATED COSTS TO ACHIEVE

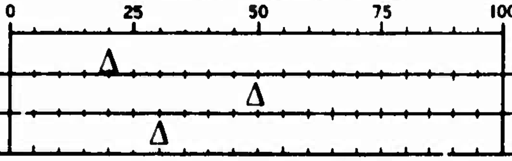
N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	1.5	.5 M	.90 M	0 - 1.81
9	UPPER LIMIT	4.4	.5 M	3.06 M	.30 - 5.81

DOT ASSESSMENT RESULTS

EVENT: IIIA02 Hydraulic tools as in IIIA01, except that seawater is used as the hydraulic fluid in an open cycle.

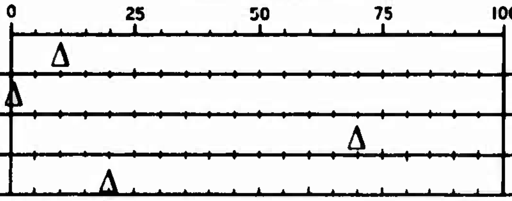
SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL			20 %	
DESIRABLE	10		50 %	DESIRABLE
UNNECESSARY		10	30 %	



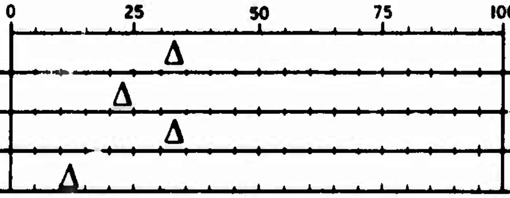
DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE		10	10 %	
.4 EXPERIMENTAL			0 %	
.7 SIMULATION	20		70 %	
.9 UNPROVEN		10	20 %	



DESIRED COURSE OF ACTION

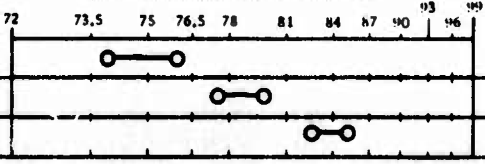
N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	27		33 %	
MEDIUM		12	22 %	
LONG		3	33 %	LONG
UNDESIRABLE		12	12 %	



PROBABLE TIMING

CALENDAR YEARS
(90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	1.8	75	75.2	2 - 4½ YRS.
9	MOST LIKELY	2.4	77,80	79.1	5½ - 8½ YRS.
9	NOT LATER THAN	2.8	85	83.7	10 - 13½ YRS.



ESTIMATED COSTS TO ACHIEVE

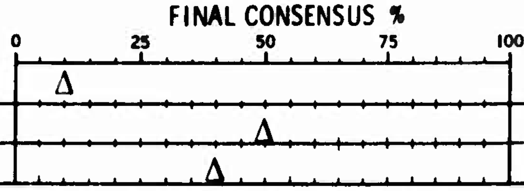
N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
8	LOWER LIMIT	6.4	5.1 M	3.06 M	0 - 7.36
8	UPPER LIMIT	15.6	5 M	8.88 M	0 - 19.35

DOT ASSESSMENT RESULTS

EVENT: IIIA03

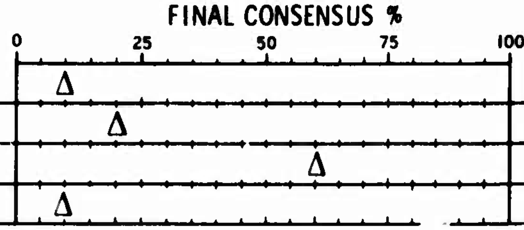
Tools such as disc and chain saws, drills, hammers, impact wrenches, etc., powered by electricity and specifically designed for underwater use by divers to depths of 1 000 ft.

SYSTEM CRITICALITY



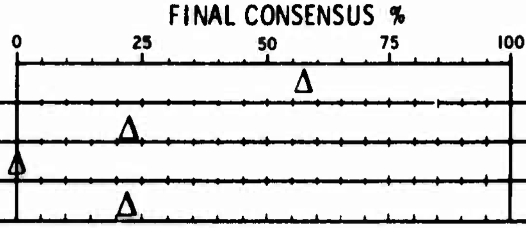
N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	10		10 %	
DESIRABLE			50 %	DESIRABLE
UNNECESSARY		10	40 %	

DEGREE OF RISK



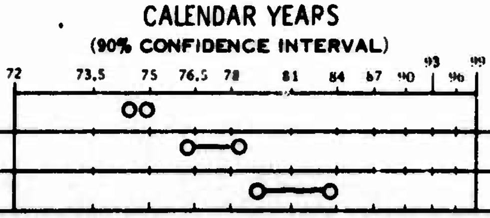
N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			10 %	
.4 EXPERIMENTAL	10		20 %	
.7 SIMULATION		20	60 %	.7
.9 UNPROVEN	10		10 %	

DESIRED COURSE OF ACTION



N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	14		56 %	SHORT
MEDIUM		2	22 %	
LONG			0 %	
UNDESIRABLE		12	22 %	

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	.4	75	74.7	2½ - 3 YRS.
9	MOST LIKELY	1.6	77,78	74.4	4½ - 6½ YRS.
9	NOT LATER THAN	2.9	80	81.4	7½ - 11 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
8	LOWER LIMIT	.6	.5,1 M	.69 M	.30 - 1.09
8	UPPER LIMIT	1.4	1 M	2.09M	1.16 - 3.03

DOT ASSESSMENT RESULTS

EVENT: IIIA04

An underwater laser surveyeing system specifically designed for diver use, capable of accurate third order angular measurement (vertical and horizontal).

SYSTEM CRITICALITY

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	11		0 %	
DESIRABLE		11	89 %	DESIRABLE
UNNECESSARY			11 %	

DEGREE OF RISK

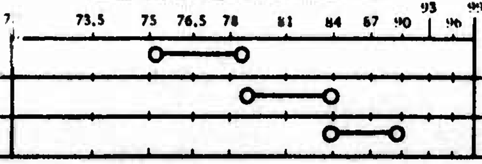
N= 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL		12.5	12.5 %	
.7 SIMULATION			62.5 %	.7
.9 UNPROVEN	12.5		25 %	

DESIRED COURSE OF ACTION

N= 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	25		0 %	
MEDIUM		37.5	87.5 %	MEDIUM
LONG	12.5		12.5 %	
UNDESIRABLE			0 %	

PROBABLE TIMING

CALENDAR YEARS
(90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
8	EARLIEST	2.5	75,80	76.9	3 - 6½ YRS.
8	MOST LIKELY	3.6	85	81.5	7 - 12 YRS.
8	NOT LATER THAN	4.4	90	86.9	12 - 18 YRS.

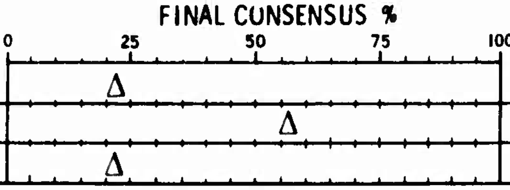
ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
7	LOWER LIMIT	17.0	.2,.5 M	9.06 M	0 - 21.56
7	UPPER LIMIT	50.6	N/A M	26.93 M	0 - 64.12

DOT ASSESSMENT RESULTS

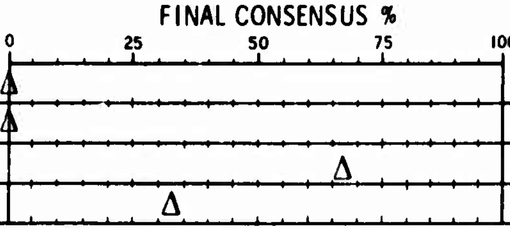
EVENT: IIIA05 An underwater optical surveying system ... same as IIIA04

SYSTEM CRITICALITY



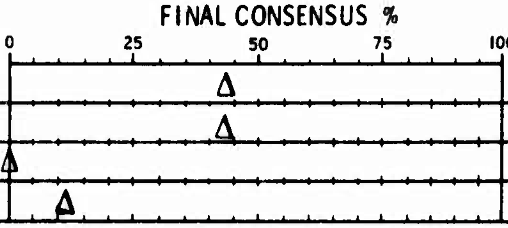
N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	8		22 %	
DESIRABLE		6	56 %	DESIRABLE
UNNECESSARY		2	22 %	

DEGREE OF RISK



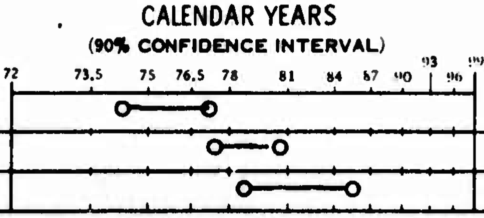
N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL	10		0 %	
.7 SIMULATION		17	67 %	.7
.9 UNPROVEN	7		33 %	

DESIRED COURSE OF ACTION



N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	5.5		44.5 %	
MEDIUM		4.5	44.5 %	MEDIUM
LONG			0 %	
UNDESIRABLE		1	11 %	

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
8	EARLIEST	1.9	75	75.4	2 - 4½ YRS.
8	MOST LIKELY	2.9	80	78.9	5 - 9 YRS.
8	NOT LATER THAN	4.1	85	82.6	8 - 13½ YRS.

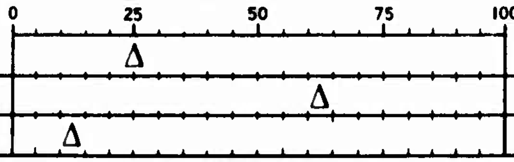
ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
7	LOWER LIMIT	3.4	N/A M	1.76M	0 - 4.24
7	UPPER LIMIT	8.5	.5,10 M	6.82 M	.61 - 13.04

DOT ASSESSMENT RESULTS

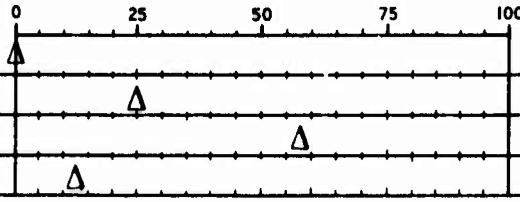
EVENT: IIIA06 An underwater acoustic surveying system ... same as IIIA04 ...

SYSTEM CRITICALITY



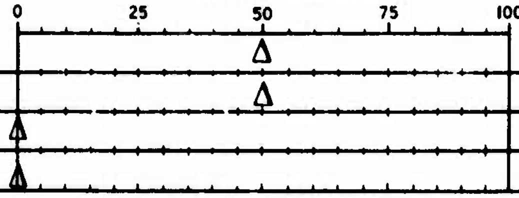
N= 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL		3	25 %	
DESIRABLE	15.5		62.5%	DESIRABLE
UNNECESSARY		12.5	12.5%	

DEGREE OF RISK



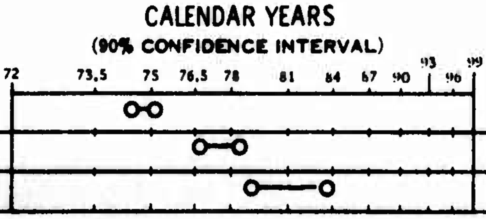
N= 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL		14	25 %	
.7 SIMULATION	4.5		62.5 %	.7
.9 UNPROVEN	9.5		12.5 %	

DESIRED COURSE OF ACTION



N= 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	17		50 %	
MEDIUM		28	50 %	MEDIUM
LONG	11		0 %	
UNDESIRABLE			0 %	

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
8	EARLIEST	.6	75	74.8	2½ - 3 YRS.
8	MOST LIKELY	1.3	77	77.6	4½ - 6½ YRS.
8	NOT LATER THAN	2.4	81,85	81.5	8 - 11 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
7	LOWER LIMIT	2.0	.5M	1.98 M	.52 - 3.43
7	UPPER LIMIT	7.4	1 M	6.25M	.84 - 11.66

IIIB Sub-Technology: Site Preparation and Selection

Objective: To develop the technologies and techniques by which a seafloor site at 8,000-ft depths can be prepared as a habitat construction site. The following operational objectives are to be undertaken:

- Excavation, trenching, and dredging of bottom soils
- Seafloor soil transportation and filling
- Soil mass stabilization
- Site appraisal

Events IIIB01 - IIIB06 address this objective.

DOT ASSESSMENT RESULTS

EVENT:	IIIB01	Determination of the stability of a submarine slope at water depths of 20,000 ft, using analytical techniques based on physical measurements of the topography, structure, and strength of the sediment.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL	13		Δ	60 %	ESSENTIAL
DESIRABLE		11	Δ	20 %	
UNNECESSARY		2	Δ	20 %	

DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL	8		Δ	10 %	
.7 SIMULATION		17	Δ	90 %	.7
.9 UNPROVEN	9		Δ	0 %	

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL		3	Δ	30 %	
MEDIUM	5		Δ	50 %	MEDIUM
LONG		2	Δ	20 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 67 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	o—o	.9	75	74.8	2½ - 3½ YRS.
10	MOST LIKELY	o—o	2.8	80	79.0	5½ - 8½ YRS.
10	NOT LATER THAN	o—o	3.7	80,85	84.0	10 - 14 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	1.6	.2 M	1.11 M	.11 - 2.12
9	UPPER LIMIT	3.0	5 M	3.13 M	1.30 - 4.97

DOT ASSESSMENT RESULTS

EVENT: IIIB02

Stabilization of an area of ocean sediments 100 yds square at a water depth of 8,000 ft, which would otherwise fail in a mass sediment slide when a structure with a submerged weight of 100 tons is placed with a raft foundation on the slope.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	7		20 %	
DESIRABLE		3	30 %	
UNNECESSARY		4	50 %	UNNECESSARY

DEGREE OF RISK

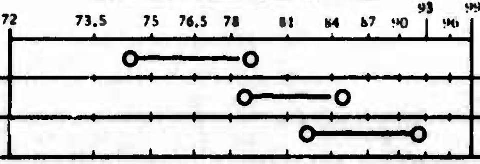
N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL		1	10 %	
.7 SIMULATION		12	30 %	
.9 UNPROVEN	13		60 %	.9

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		1	20 %	
MEDIUM		4	40 %	MEDIUM
LONG	9		0 %	
UNDESIRABLE		4	40 %	UNDESIRABLE

PROBABLE TIMING

CALENDAR YEARS
(90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	3.6	75	76.4	2 - 6½ YRS.
9	MOST LIKELY	5.3	80	81.6	6½ - 13 YRS.
9	NOT LATER THAN	8.0	85	87.6	10½ - 20½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
8	LOWER LIMIT	1.2	.5,1 M	1.17M	.36 - 1.98
8	UPPER LIMIT	3.7	5 M	4.31M	1.85 - 6.77

DOT ASSESSMENT RESULTS

EVENT: IIIB03

A bottom crawling remotely operated vehicle, with a rotary cutter and slurry suction removal system, that performs leveling, excavation, and trenching at a rate of 50 cubic yds/hr in unconsolidated mud and 20 cubic yds/hr in a dense sandy sediment, at a water depth of 8,000 ft on slopes of at least 10^{o}, producing a finished cut with a tolerance of ± 6 inches.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	7		20 %	
DESIRABLE		6	70 %	DESIRABLE
UNNECESSARY		1	10 %	

DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL	6		30 %	
.7 SIMULATION	5		50 %	.7
.9 UNPROVEN		11	20 %	

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	4		60 %	SHORT
MEDIUM		3	30 %	
LONG			0 %	
UNDESIRABLE		1	10 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

72 73.5 75 76.5 78 81 84 87 90 93 96 99

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	1.7	75	75.7	2½ - 4½ YRS.
10	MOST LIKELY	2.1	80	80.0	7 - 9 YRS.
10	NOT LATER THAN	4.6	85	85.1	10½ - 16 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	2.1	5 M	2.61M	1.28 - 3.94
9	UPPER LIMIT	14.2	5 M	11.44M	2.61 - 20.27

DOT ASSESSMENT RESULTS

EVENT: IIIB04 A swimming remotely operated vehicle, with ...
same as IIIB03 ...

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL			0 %	
DESIRABLE	5.5		40 %	
UNNECESSARY		5.5	60 %	UNNECESSARY

DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL	9		0 %	
.7 SIMULATION		2	20 %	
.9 UNPROVEN		7	80 %	.9

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		1	10 %	
MEDIUM	9		10 %	
LONG		14	50 %	LONG
UNDESIRABLE	6		30 %	

PROBABLE TIMING

CALENDAR YEARS
(90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	3.3	75	77.4	3½ - 7½ YRS.
9	MOST LIKELY	3.5	80	81.8	7½ - 12 YRS.
9	NOT LATER THAN	4.2	85	86.8	12 - 17½ YRS.

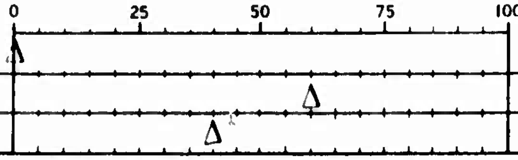
ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
8	LOWER LIMIT	15.8	1 M	9.44 M	0 - 20.02
8	UPPER LIMIT	39.7	5 M	32.13 M	5.51 - 58.74

DOT ASSESSMENT RESULTS

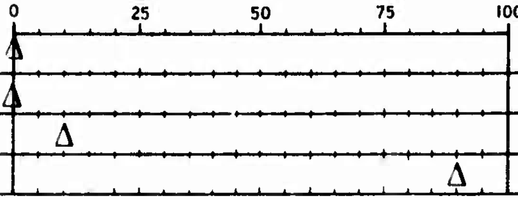
EVENT: IIIB05 A vehicle ramotely operated with articulated legs, with ... same as IIIB03 ...

SYSTEM CRITICALITY



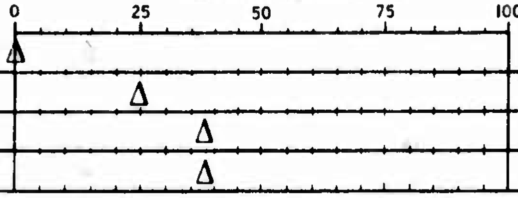
N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL			0 %	
DESIRABLE		5.5	60 %	DESIRABLE
UNNECESSARY	5.5		40 %	

DEGREE OF RISK



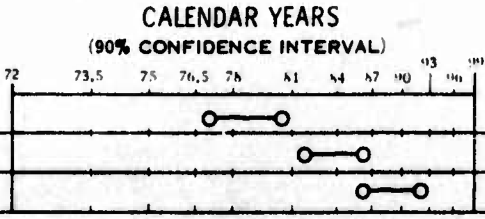
N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL	9		0 %	
.7 SIMULATION	8		10 %	
.9 UNPROVEN		17	90 %	.9

DESIRED COURSE OF ACTION



N= 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			0 %	
MEDIUM	11		25 %	
LONG		1.5	37.5 %	
UNDESIRABLE		9.5	37.5 %	UNDESIRABLE

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	3.2	78	78.8	5 - 8½ YRS.
9	MOST LIKELY	3.8	85	84.1	15½-14½ YRS.
9	NOT LATER THAN	4.6	90	89.3	14½-20 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
8	LOWER LIMIT	15.7	5 M	11.69 M	1.19 - 22.18
8	UPPER LIMIT	31.6	10 M	30.38 M	9.18 - 51.57

DOT ASSESSMENT RESULTS

EVENT: IIIB06

A slurry transport system remotely operated capable of transporting cut sediments a distance of 1 mile at a rate of 50 cubic yds/hr to a controlled fill area at a depth of 8,000 ft.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	9		0 %	
DESIRABLE		7	80 %	DESIRABLE
UNNECESSARY		2	20 %	

DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL		11	20 %	
.7 SIMULATION	5.5		40 %	.7
.9 UNPROVEN	5.5		40 %	.9

DESIRED COURSE OF ACTION

N= 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		14	50 %	SHORT
MEDIUM	11		25 %	
LONG		3.5	12.5%	
UNDESIRABLE	6.5		12.5%	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
8	EARLIEST	2.1	75	75.1	1½ - 4½ YRS.
8	MOST LIKELY	3.2	80	79.3	5 - 9½ YRS.
8	NOT LATER THAN	4.3	90	85.3	10½ - 16 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	3.9	1 M	3.21M	.81 - 5.62
9	UPPER LIMIT	14.9	10 M	11.28M	2.04 - 20.52

IIIC Sub-Technology **On-Bottom Construction**

Objective: To develop the techniques and technologies to assemble, weld, bolt, and/or cement prefabricated components of large structures, to make or emplace foundations and pilings for support of the structures, and/or pour concrete in-place on the seafloor at depths of 8,000 ft.

Events IIIC01 - IIIC24 address this objective.

DOT ASSESSMENT RESULTS

EVENT: IIIC01

On the basis of seismic response measurements of an ocean floor site and calculated hydrodynamic loads, the capability to design a pressure resistant structure enclosing a volume of 20,000 ft^3 (may be interconnected modules) at a depth of 8,000 ft which can survive an earthquake that measures 7.5 on the Richter Scale, with the structure located above or near the epicenter.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL			0 %	
DESIRABLE	4		60 %	DESIRABLE
UNNECESSARY		4	40 %	

DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL			0 %	
.7 SIMULATION		4	40 %	
.9 UNPROVEN	4		60 %	.9

DESIRED COURSE OF ACTION

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			0 %	
MEDIUM	4		56 %	MEDIUM
LONG		13	33 %	
UNDESIRABLE	9		11 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL)	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST		4.0	78,80	79.6	5 - 10 YRS.
9	MOST LIKELY		4.5	85	84.3	9½ - 15 YRS.
9	NOT LATER THAN		4.0	90	89.2	14½ - 19½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
8	LOWER LIMIT	7.0	5 M	7.50 M	2.83 - 12.17
8	UPPER LIMIT	23.2	15,50 M	30.63 M	15.34 - 45.91

DOT ASSESSMENT RESULTS

EVENT: IIIC02

A concrete overlay, poured in place at a depth of 8,000 ft, following gentle contours of the sediment (may be preleveled), which can support a load of 100 lbs/ft^2.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 · 25 · 50 · 75 · 100)		CONCLUSION
ESSENTIAL	7		Δ	20 %	
DESIRABLE		5	Δ	60 %	DESIRABLE
UNNECESSARY		2	Δ	20 %	

DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 · 25 · 50 · 75 · 100)		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL		11	Δ	20 %	
.7 SIMULATION	15		Δ	40 %	
.9 UNPROVEN		4	Δ	40 %	.9

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 · 25 · 50 · 75 · 100)		CONCLUSION
SHORT RANGE GOAL		1	Δ	10 %	
MEDIUM		6	Δ	70 %	MEDIUM
LONG	9		Δ	0 %	
UNDESIRABLE		2	Δ	20 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) (72 · 73.5 · 75 · 76.5 · 78 · 81 · 84 · 87 · 90 · 93 · 96 · 99)	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	o--o	1.9	78	76.7	3 1/2 - 6 YRS
9	MOST LIKELY	o---o	3.4	85	80.9	7 - 11 YRS
9	NOT LATER THAN	o--o	3.9	85,90	84.9	10 1/2 - 15 1/2 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
8	LOWER LIMIT	3.0	1 M	2.27 M	.22 - 4.32
8	UPPER LIMIT	5.8	10 M	7.78 M	3.88 - 11.67

DOT ASSESSMENT RESULTS

EVENT: IIIC03

Interlocking preformed concrete slabs assembled at a depth of 8,000 ft, forming a mat following --- same as IIIC02 ...

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL			Δ	0 %	
DESIRABLE	1		Δ	90 %	DESIRABLE
UNNECESSARY		1	Δ	10 %	

DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL		10	Δ	10 %	
.7 SIMULATION	13		Δ	60 %	.7
.9 UNPROVEN		3	Δ	30 %	

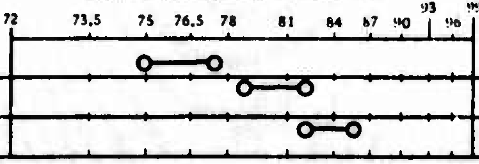
DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL		1	Δ	10 %	
MEDIUM		15	Δ	70 %	MEDIUM
LONG	26		Δ	10 %	
UNDESIRABLE		10	Δ	10 %	

PROBABLE TIMING

CALENDAR YEARS

(90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	2.2	74,76	76.3	3 - 5½ YRS.
10	MOST LIKELY	3.1	78	80.6	7 - 10½ YRS.
10	NOT LATER THAN	4.3	80,90	84.3	10 - 15 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	1.9	.5 M	1.63 M	.46 - 2.80
9	UPPER LIMIT	3.7	2.10 M	5.13 M	2.81 - 7.44

DOT ASSESSMENT RESULTS

EVENT: IIIC04

Large fabric "air-mattress" bags (Fabri-Form) filled with a grout slurry at a depth of 8,000 ft ... same as IIIC02 ...

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL			0 %	
DESIRABLE	2		80 %	DESIRABLE
UNNECESSARY		2	20 %	

DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL			0 %	
.7 SIMULATION	3		70 %	.7
.9 UNPROVEN		3	30 %	

DESIRED COURSE OF ACTION

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		11	11 %	
MEDIUM	13		67 %	MEDIUM
LONG		1	11 %	
UNDESIRABLE		1	11 %	

PROBABLE TIMING

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
8	EARLIEST	3.4	75	76.1	2 - 6½ YRS.
8	MOST LIKELY	4.2	80	80.0	5 - 11 YRS
8	NOT LATER THAN	5.2	85	84.9	9½-16½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
6	LOWER LIMIT	1.6	1 M	1.59 M	.25 - 2.94
6	UPPER LIMIT	2.8	5 M	4.69 M	2.27 - 7.11

DOT ASSESSMENT RESULTS

EVENT: IIIC05

A plastic film overlay placed on easily distrubed sediments to control turbidity. The film is placed by a submersible at a rate of 50 square yds/hr, at a depth of 8,000 ft, and can support a load of 10 lbs/ft^2.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL		1	10 %	
DESIRABLE		6	70 %	DESIRABLE
UNNECESSARY	7		20 %	

DEGREE OF RISK

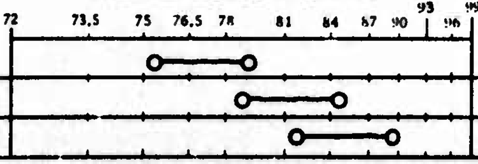
N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL	9		0 %	
.7 SIMULATION		4	40 %	
.9 UNPROVEN		5	60 %	.9

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	8		10 %	
MEDIUM		5	60 %	MEDIUM
LONG		2	20 %	
UNDESIRABLE		1	10 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	3.6	76,80	77.2	3 - 7½ YRS.
10	MOST LIKELY	4.9	85	81.6	6½ - 12½ YRS.
10	NOT LATER THAN	6.9	90	85.8	10 - 18 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	21.2	.5 M	9.97M	0 -24.35
9	UPPER LIMIT	46.1	2 M	27.03M	0 -55.64

DOT ASSESSMENT RESULTS

EVENT: IIIC06

A chemical flocculating agent capable of rapid precipitation of suspended particles (sediments, etc) in seawater, eliminating turbid condition for increased visibility. The agent must be capable of increasing the sedimentation rate such that suspended sediments are precipitated within 24 hours and/or prior to the diffusion of the flocculating agent into the surrounding water.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL		13	Δ	40 %	
DESIRABLE	13		Δ	60 %	DESIRABLE
UNNECESSARY			Δ	0 %	

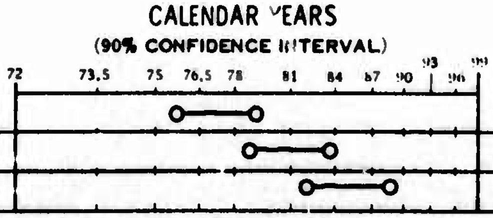
DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE				0 %	
.4 EXPERIMENTAL		2	Δ	20 %	
.7 SIMULATION		1	Δ	10 %	
.9 UNPROVEN	3		Δ	70 %	.9

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL		13	Δ	40 %	SHORT
MEDIUM	7		Δ	30 %	
LONG		3	Δ	30 %	
UNDESIRABLE	9		Δ	0 %	

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	3.0	80	77.5	3½ - 7½ YRS.
10	MOST LIKELY	4.3	85	81.3	7 - 12 YRS.
10	NOT LATER THAN	5.3	90	85.4	10½ - 16½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
8	LOWER LIMIT	4.8	.5 M	2.65 M	0 - 5.85
8	UPPER LIMIT	9.5	2,10 M	6.92 M	.54 - 13.30

DOT ASSESSMENT RESULTS

EVENT:	
IIIC07	A manned crawling vehicle, capable of powering, positioning and controlling with interchangeable subsystems (manipulators, excavating head, etc) and capable of accomplishing construction at a depth of 8,000 ft on slopes as great as 10°. The vehicle has a payload capacity of 5 tons submerged weight.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL		12	30 %	
DESIRABLE	14		50 %	DESIRABLE
UNNECESSARY		2	20 %	

DEGREE OF RISK

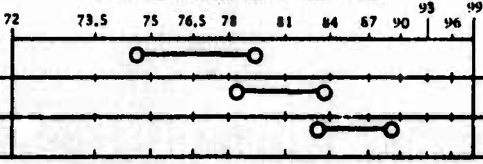
N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL		2	20 %	
.7 SIMULATION		3	30 %	
9 UNPROVEN	5		50 %	.9

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			50 %	SHORT
MEDIUM	10		20 %	
LONG			10 %	
UNDESIRABLE		10	20 %	

PROBABLE TIMING

CALENDAR YEARS
(90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
8	EARLIEST	3.3	75	76.9	2½ - 7 YRS.
8	MOST LIKELY	4.1	80	81.1	6½ - 12 YRS.
8	NOT LATER THAN	4.6	85	86.5	11½ - 17½ YRS.

ESTIMATED COSTS TO ACHIEVE

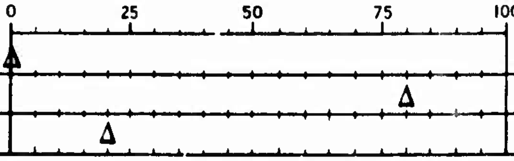
N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
7	LOWER LIMIT	1.7	1 M	2.36	1.10 - 3.61
7	UPPER LIMIT	7.1	None M	10.4 M	5.24 - 15.62

DOT ASSESSMENT RESULTS

EVENT: IIIC08

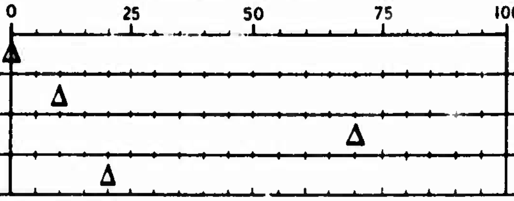
A raft-type foundation for large, heavy structures (100 ft x 100 ft) with a differential settlement of less than 3 inches under uniform load of 5 lbs per square foot. The sediment is ooze 50 ft deep at water depth of 8,000 ft.

SYSTEM CRITICALITY



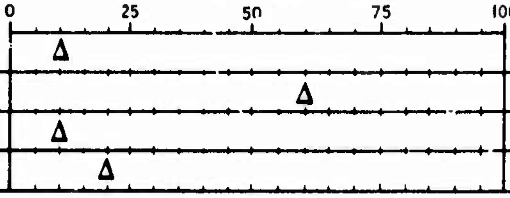
N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	9		0 %	
DESIRABLE		7	80 %	DESIRABLE
UNNECESSARY		2	20 %	

DEGREE OF RISK



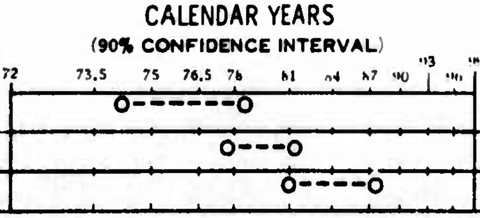
N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL		1	10 %	
.7 SIMULATION	3		70 %	.7
.9 UNPROVEN		2	20 %	

DESIRED COURSE OF ACTION



N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			10 %	
MEDIUM	10		60 %	MEDIUM
LONG			10 %	
UNDESIRABLE		10	20 %	

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
8	EARLIEST	3.4	75	76.3	2 - 6½ YRS
8	MOST LIKELY	4.1	80	80.1	5½ - 11 YRS
8	NOT LATER THAN	4.8	85	84.3	9 - 15½ YRS.

ESTIMATED COSTS TO ACHIEVE

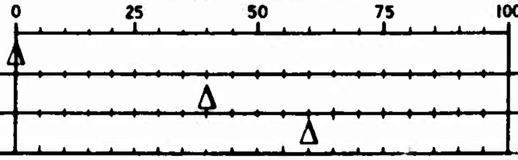
N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
7	LOWER LIMIT	1.1	1 M	1.29M	.46 - 2.12
7	UPPER LIMIT	2.7	2 M	4.07M	2.07 - 6.08

DOT ASSESSMENT RESULTS

EVENT: IIIC09	A buoyancy controlled foundation (total and differential settlement controlled by varying the buoyancy of the structure at different points) for large, heavy structures ... same as IIIC08 ...

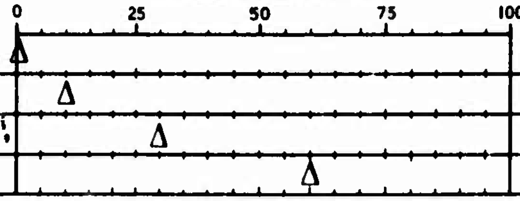
SYSTEM CRITICALITY

	PERCENTAGE		FINAL CONSENSUS %	CONCLUSION
N= 10	LOSS	GAIN		
ESSENTIAL	9		0 %	
DESIRABLE	5.5		40 %	
UNNECESSARY		14.5	60 %	UNNECESSARY



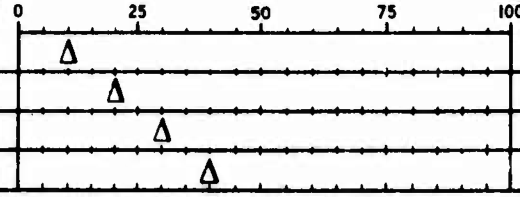
DEGREE OF RISK

	PERCENTAGE		FINAL CONSENSUS %	CONCLUSION
N= 10	LOSS	GAIN		
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL	8		10 %	
.7 SIMULATION	6		30 %	
.9 UNPROVEN		14	60 %	.9



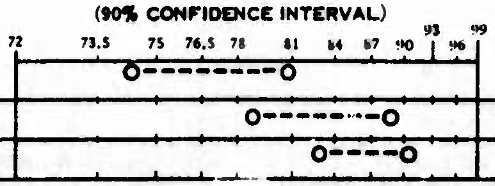
DESIRED COURSE OF ACTION

	PERCENTAGE		FINAL CONSENSUS %	CONCLUSION
N= 10	LOSS	GAIN		
SHORT RANGE GOAL			10 %	
MEDIUM	20		20 %	
LONG		10	30 %	
UNDESIRABLE		10	40 %	UNDESIRABLE



PROBABLE TIMING

CALENDAR YEARS
(90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
8	EARLIEST	5.0	75	77.5	2 - 9 YRS.
8	MOST LIKELY	6.1	80	83.0	7 - 15 YRS.
8	NOT LATER THAN	6.0	85,95	87.6	11½ - 19½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
7	LOWER LIMIT	1.0	1 M	2.00 M	1.21 - 2.79
7	UPPER LIMIT	4.3	3,10M	7.14 M	4.02 - 10.27

DOT ASSESSMENT RESULTS

EVENT: IIIC10 A foundation with total and differential settlement controlled by individually extendable piles (telescoping), for ... same as IIIC08 ...

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL			0 %	
DESIRABLE	11		80 %	DESIRABLE
UNNECESSARY		11	20 %	

DEGREE OF RISK

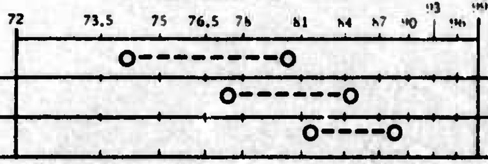
N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL	9		0 %	
.7 SIMULATION	2		80 %	.7
.9 UNPROVEN		11	20 %	

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			0 %	
MEDIUM	4		60 %	MEDIUM
LONG	6		30 %	
UNDESIRABLE		10	10 %	

PROBABLE TIMING

CALENDAR YEARS
(90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	5.0	75	77.0	2 - 8 YRS.
9	MOST LIKELY	5.7	76,80	80.8	5 - 12½ YRS
9	NOT LATER THAN	5.0	85	84.6	9½ - 15½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
8	LOWER LIMIT	1.1	1 M	1.44 M	.72 - 2.16
8	UPPER LIMIT	3.1	3,10M	4.94 M	2.86 - 7.02

DOT ASSESSMENT RESULTS

EVENT: IIIC11 A pile foundation, drilled to a depth of 200 ft into the sediments, for ... same as IIIC08 ...

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	17		10 %	
DESIRABLE		23	50 %	DESIRABLE
UNNECESSARY	6		40 %	

DEGREE OF RISK

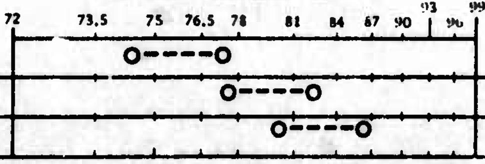
N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL	6		40 %	
.7 SIMULATION		2	20 %	
.9 UNPROVEN		4	40 %	.9

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			0 %	
MEDIUM	20		40 %	
LONG		10	40 %	LONG
UNDESIRABLE		10	20 %	

PROBABLE TIMING

CALENDAR YEARS
(90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
7	EARLIEST	1.9	75	75.4	2 - 5 YRS.
7	MOST L!KELY	2.9	80	79.3	5 - 9½ YRS.
7	NOT LATER THAN	4.6	80,90	83.4	8 - 15 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
7	LOWER LIMIT	1.0	.5,2 M	1.30 M	.58 - 2.02
7	UPPER LIMIT	3.7	10 M	4.61 M	1.88 - 7.30

DOT ASSESSMENT RESULTS

EVENT: IIIC12 A pile foundation, water-jetted to a depth of 200 ft into the sediments for ... same as IIIC08 ...

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	9		0 %	
DESIRABLE		6	70 %	DESIRABLE
UNNECESSARY		3	30 %	

DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL		2	20 %	
.7 SIMULATION	17		10 %	
.9 UNPROVEN		15	70 %	.9

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			0 %	
MEDIUM	10		70 %	MEDIUM
LONG			20 %	
UNDESIRABLE		10	10 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
8	EARLIEST	.5	75	75.0	2½ - 3½ YRS.
8	MOST LIKELY	2.6	80	80.0	6½ - 9½ YRS.
8	NOT LATER THAN	3.1	85	84.4	10½ - 14½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
8	LOWER LIMIT	1.0	.5,2 M	1.17M	.51 - 1.82
8	UPPER LIMIT	4.0	2,10M	4.94M	2.28 - 7.60

DOT ASSESSMENT RESULTS

EVENT: IIIC13 — A pile foundation, vibrated to a depth of 200 ft into the sediment for...same as IIIC08.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	9		0 %	
DESIRABLE		17	90 %	DESIRABLE
UNNECESSARY	8		10 %	

DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL	8		10 %	
.7 SIMULATION		3	30 %	
.9 UNPROVEN		5	60 %	.9

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			0 %	
MEDIUM	10		70 %	MEDIUM
LONG			20 %	
UNDESIRABLE		10	10 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL)	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
8	EARLIEST	o–o	.6	75	75.1	2½ - 3½ YRS.
8	MOST LIKELY	o–o	1.8	80	79.4	6 - 8½ YRS.
8	NOT LATER THAN	o--o	3.2	85	84.4	10½ - 14½ YRS.

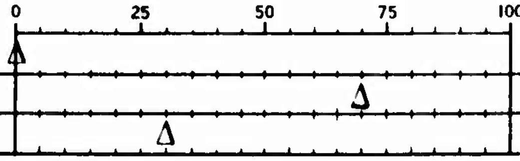
ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
8	LOWER LIMIT	1.5	.5,1 M	1.29M	.27 - 2.30
8	UPPER LIMIT	4.0	2,10 M	4.94M	2.28 - 7.60

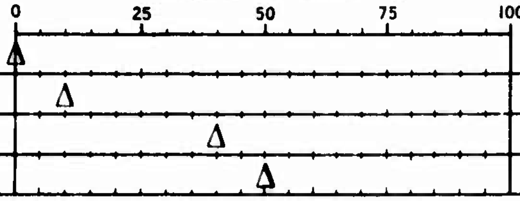
DOT ASSESSMENT RESULTS

EVENT: IIIC14 A pile foundation, driven to a depth of 200 ft. into the sediment for...same as IIIC08.

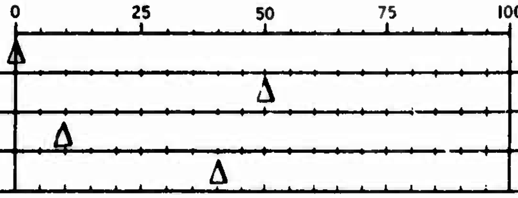
SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 		CONCLUSION
ESSENTIAL				0 %	
DESIRABLE	12			70 %	DESIRABLE
UNNECESSARY		12		30 %	

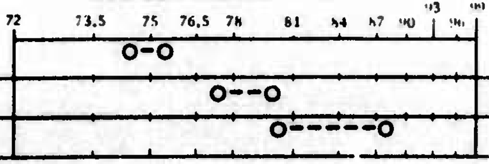
DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 		CONCLUSION
.1 PROTOTYPE				0 %	
.4 EXPERIMENTAL	8			10 %	
.7 SIMULATION		4		40 %	
.9 UNPROVEN		4		50 %	.9

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 		CONCLUSION
SHORT RANGE GOAL				0 %	
MEDIUM	20			50 %	MEDIUM
LONG	10			10 %	
UNDESIRABLE		30		40 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
7	EARLIEST		.3	75	74.9	2½ - 3 YRS.
7	MOST LIKELY		2.0	80	78.9	5½ - 8½ YRS
7	NOT LATER THAN		4.5	85,90	84.0	8½ - 15½ YRS

ESTIMATED COSTS TO ACHIEVE

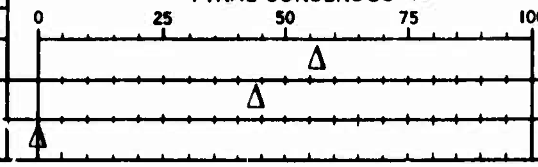
N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
7	LOWER LIMIT	2.6	.1,1 M	1.81 M	0 - 3.72
7	UPPER LIMIT	6.5	2,10 M	6.77 M	1.99 - 11.55

DOT ASSESSMENT RESULTS

EVENT: IIIC15

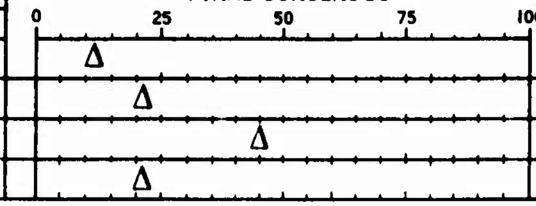
A vibratory anchor capable of holding 20,000 lbs at depths to 20,000 ft in bottom conditions ranging from ooze to coarse sand and slopes up to 10 degrees, to be installed with a remote retrievable/ reuseable power unit.

SYSTEM CRITICALITY



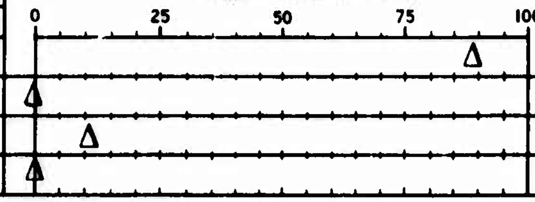
N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL		16	56 %	ESSENTIAL
DESIRABLE	16		44 %	
UNNECESSARY			0 %	

DEGREE OF RISK



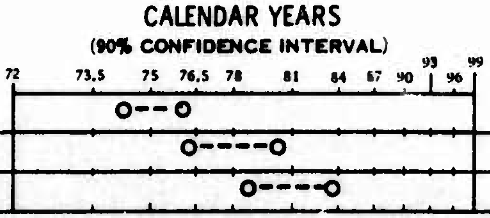
N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE		1	11 %	
.4 EXPERIMENTAL		2	22 %	
.7 SIMULATION	5		45 %	.7
.9 UNPROVEN		2	22 %	

DESIRED COURSE OF ACTION



N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		9	89 %	SHORT
MEDIUM	10		0 %	
LONG		1	11 %	
UNDESIRABLE			0 %	

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	1.8	74	75.2	2 - 4½ YRS.
8	MOST LIKELY	3.1	76	78.5	4½ - 8½ YRS.
8	NOT LATER THAN	3.8	80	81.4	7 - 12 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
8	LOWER LIMIT	1.6	.2 M	.88 M	0 - 1.93
8	UPPER LIMIT	4.6	1 M	2.85 M	0 - 5.95

DOT ASSESSMENT RESULTS

EVENT: IIIC16 A vibratory anchor capable of holding 300,000 lbs
... same as IIIC15 ...

SYSTEM CRITICALITY

N= 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL		14		25 %	
DESIRABLE	15.5			62.5 %	DESIRABLE
UNNECESSARY		1.5		12.5 %	

DEGREE OF RISK

N= 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE				0 %	
.4 EXPERIMENTAL				0 %	
.7 SIMULATION	20.5			12.5 %	
.9 UNPROVEN		20.5		87.5 %	.9

DESIRED COURSE OF ACTION

N= 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL	22			0 %	
MEDIUM		20.5		87.5 %	MEDIUM
LONG				0 %	
UNDESIRABLE		1.5		12.5 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
7	EARLIEST		1.0	75,76	75.9	3 - 4½ YRS
7	MOST LIKELY		1.4	80	79.7	6½ - 8½ YRS
7	NOT LATER THAN		2.9	85	84.6	10½ - 14½ YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
7	LOWER LIMIT	3.3	1 M	1.99M	0 - 4.41
7	UPPER LIMIT	6.4	2 M	4.64M	0 - 9.35

DOT ASSESSMENT RESULTS

EVENT: IIIC17 A waterjet anchor capable of holding 20,000 lbs
... same as IIIC15 ...

SYSTEM CRITICALITY

N= 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL		1.5	Δ	12.5 %	
DESIRABLE	3		Δ	75 %	DESIRABLE
UNNECESSARY		1.5	Δ	12.5 %	

DEGREE OF RISK

N= 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE		1.5	Δ	12.5 %	
.4 EXPERIMENTAL	11		Δ	0 %	
.7 SIMULATION	8		Δ	25 %	
.9 UNPROVEN		17.5	Δ	62.5 %	.9

DESIRED COURSE OF ACTION

N= 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL		15.5	Δ	37.5 %	SHORT
MEDIUM	18.5		Δ	37.5 %	
LONG		1.5	Δ	12.5 %	
UNDESIRABLE		1.5	Δ	12.5 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
7	EARLIEST	O-O	.4	75	75.3	3 - 3½ YRS.
7	MOST LIKELY	O-O	1.2	80	79.0	6 - 8 YRS.
7	NOT LATER THAN	O---O	2.7	85	82.1	8 - 12 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
7	LOWER LIMIT	1.5	1 M	1.31M	.19 - 2.44
7	UPPER LIMIT	3.8	1.5 M	3.79M	1.01 - 6.56

DOT ASSESSMENT RESULTS

EVENT: IIIC18 A waterjet anchor capable of holding 300,000 lbs
... same as IIIC15 ...

SYSTEM CRITICALITY

N= 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL			Δ	0 %	
DESIRABLE	4.5		Δ	62.5 %	DESIRABLE
UNNECESSARY		4.5	Δ	37.5 %	

DEGREE OF RISK

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL		11	Δ	22 %	
.7 SIMULATION	22		Δ	0 %	
.9 UNPROVEN		11	Δ	78 %	.9

DESIRED COURSE OF ACTION

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL		11	Δ	11 %	
MEDIUM	11		Δ	45 %	MEDIUM
LONG		11	Δ	11 %	
UNDESIRABLE	11		Δ	33 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) (72 73.5 75 76.5 78 81 84 87 90 93 96 99)	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
7	EARLIEST	o—o	2.2	80	78.1	4½ - 7½ YRS.
7	MOST LIKELY	o--o	2.4	85	83.0	9 - 13 YRS
7	NOT LATER THAN	o-o	2.5	90	87.9	14 - 17½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
5	LOWER LIMIT	3.7	.5,1 M	2.60 M	0 - 6.13
5	UPPER LIMIT	7.1	2 M	6.00 M	0 - 12.80

DOT ASSESSMENT RESULTS

EVENT:	IIIC19	An explosive anchor capable of holding 20,000 lbs at depths to 20,000 ft in bottom conditions ranging from ooze to hard rock, and slopes up to 10 degrees, to be remotely installed.

SYSTEM CRITICALITY

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL		10.5	Δ	56 %	ESSENTIAL
DESIRABLE	10.5		Δ	44 %	
UNNECESSARY			Δ	0 %	

DEGREE OF RISK

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE		1	Δ	11 %	
.4 EXPERIMENTAL		15	Δ	45 %	.4
.7 SIMULATION	17		Δ	33 %	
.9 UNPROVEN		1	Δ	11 %	

DESIRED COURSE OF ACTION

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL		9	Δ	89 %	SHORT
MEDIUM	10		Δ	0 %	
LONG		1	Δ	11 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	o--o	1.8	75	75.2	2 - 4½ YRS.
9	MOST LIKELY	o--o	2.6	77	78.7	5 - 8½ YRS.
9	NOT LATER THAN	o----o	3.8	80	81.8	7½ - 12 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
8	LOWER LIMIT	1.5	.5 M	1.23 M	.20 - 2.25
8	UPPER LIMIT	3.1	1 M	2.78 M	.71 - 4.84

DOT ASSESSMENT RESULTS

EVENT: IIIC20 An explosive anchor capable of holding 300,000 lbs at depths to...same as IIIC19.

SYSTEM CRITICALITY

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL		11	Δ	11 %	
DESIRABLE	12		Δ	78 %	DESIRABLE
UNNECESSARY		1	Δ	11 %	

DEGREE OF RISK

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL		1	Δ	11 %	
.7 SIMULATION		2	Δ	22 %	
.9 UNPROVEN	3		Δ	67 %	.9

DESIRED COURSE OF ACTION

N= 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL			Δ	50 %	SHORT
MEDIUM	2.5		Δ	37.5 %	
LONG			Δ	0 %	
UNDESIRABLE		2.5	Δ	12.5 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
8	EARLIEST	o---o	1.8	76	77.0	4 - 6 YRS.
8	MOST LIKELY	o--o	2.9	82	80.9	7 - 11 YRS
8	NOT LATER THAN	o--o	3.8	85	84.5	10 - 15 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
7	LOWER LIMIT	3.4	.4, .5 M	2.54 M	.04 - 5.05
7	UPPER LIMIT	6.5	2 M	5.70 M	.94 - 10.46

DOT ASSESSMENT RESULTS

EVENT: IIIC21

An automatic remote rock bolt driving device capable of holding 300,000 lbs at depths to 20,000 ft in coral or rock bottoms of up to 10 degrees slope. To be installed by means of a retrievable/reuseable power unit.

SYSTEM CRITICALITY

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL		1	Δ	11 %	
DESIRABLE	2		Δ	78 %	DESIRABLE
UNNECESSARY		1	Δ	11 %	

DEGREE OF RISK

N= 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL	10		Δ	0 %	
.7 SIMULATION	20		Δ	0 %	
.9 UNPROVEN		30	Δ	100 %	.9

DESIRED COURSE OF ACTION

N= 7	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL	6		Δ	14 %	
MEDIUM	7		Δ	43 %	MEDIUM
LONG		9	Δ	29 %	
UNDESIRABLE		4	Δ	14 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
7	EARLIEST	O--O	1.4	77	77.1	4 - 6 YRS.
7	MOST LIKELY	O--O	2.4	80,82	80.7	7 - 10½ YRS.
7	NOT LATER THAN	O--O	3.3	85	84.3	10 - 14½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
7	LOWER LIMIT	3.2	1 M	2.46 M	.14 - 4.79
7	UPPER LIMIT	7.6	5 M	7.18 M	1.59 - 12.77

DOT ASSESSMENT RESULTS

EVENT: IIIC22

The development of a padlock anchor to hold 20,000 lbs at depths to 20,000 ft in bottom conditions ranging from ooze to coarse sand and slope up to 10 degrees, to be installed by means of a remote or retrievable/reuseable power unit.

SYSTEM CRITICALITY

N= 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL			Δ	0 %	
DESIRABLE		9.5	Δ	87.5 %	DESIRABLE
UNNECESSARY	9.5		Δ	12.5 %	

DEGREE OF RISK

N= 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL		1.5	Δ	12.5 %	
.7 SIMULATION	4.5		Δ	62.5 %	.7
.9 UNPROVEN		3	Δ	25 %	

DESIRED COURSE OF ACTION

N= 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL		1.5	Δ	12.5 %	
MEDIUM		17.5	Δ	62.5 %	MEDIUM
LONG	9.5		Δ	12.5 %	
UNDESIRABLE	9.5		Δ	12.5 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL)	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
8	EARLIEST	o-o	.9	75	75.75	3 - 4½ YRS.
8	MOST LIKELY	oo	1.2	80	79.75	7 - 8½ YRS.
8	NOT LATER THAN	o--o	2.1	85	83.9	10½-13½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
8	LOWER LIMIT	1.5	.5 M	1.06 M	.04 - 2.08
8	UPPER LIMIT	3.1	1.5 M	3.09 M	.99 - 5.19

DOT ASSESSMENT RESULTS

EVENT: IIIC23 The development of a padlock anchor to hold 100,000 lbs ... same as IIIC22 ...

SYSTEM CRITICALITY

N= 8	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
ESSENTIAL		12.5	Δ	12.5 %	
DESIRABLE	8		Δ	25 %	
UNNECESSARY	4.5		Δ	62.5 %	UNNECESSARY

DEGREE OF RISK

N= 8	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL		1.5	Δ	12.5 %	
.7 SIMULATION	7		Δ	37.5 %	
.9 UNPROVEN		5.5	Δ	50 %	.9

DESIRED COURSE OF ACTION

N= 8	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
SHORT RANGE GOAL			Δ	0 %	
MEDIUM		15.5	Δ	37.5 %	
LONG	9.5		Δ	12.5 %	
UNDESIRABLE	6		Δ	50 %	UNDESIRABLE

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

N		72 73.5 75 76.5 78 81 84 87 90 93 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
5	EARLIEST	o--o	1.9	80	78.0	4 - 8 YRS.
5	MOST LIKELY	o--o	1.6	82	82.2	8½ - 11½ YRS.
5	NOT LATER THAN	o--o	2.3	87	86.4	12 - 16½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
5	LOWER LIMIT	1.9	5 M	2.70 M	.85 - 4.55
5	UPPER LIMIT	4.2	10 M	6.60 M	2.62 - 10.58

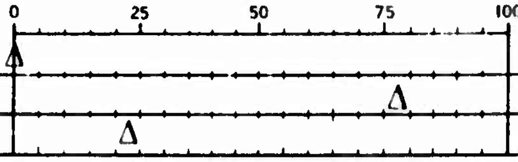
DOT ASSESSMENT RESULTS

EVENT: IIIC24

A very stable tri-moored platform, moored in 20,000 ft of water with the platform at a water depth of 2,000 ft. The platform is a sphere 12 ft in diameter, and has a buoyancy of 30,000 lbs, and will remain in fixed position for two years.

SYSTEM CRITICALITY

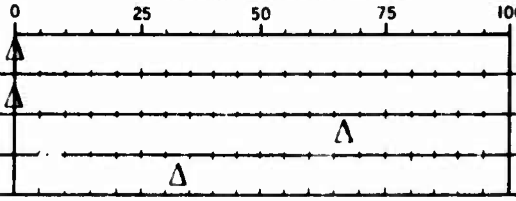
FINAL CONSENSUS %



N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	10		0 %	
DESIRABLE	2		78 %	DESIRABLE
UNNECESSARY		12	22 %	

DEGREE OF RISK

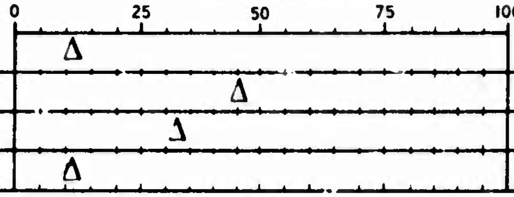
FINAL CONSENSUS %



N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL	10		0 %	
.7 SIMULATION		7	67 %	.7
.9 UNPROVEN		3	33 %	

DESIRED COURSE OF ACTION

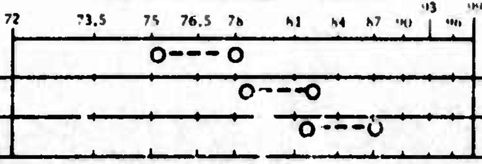
FINAL CONSENSUS %



N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		11	11 %	
MEDIUM	15		45 %	MEDIUM
LONG		3	33 %	
UNDESIRABLE		1	11 %	

PROBABLE TIMING

CALENDAR YEARS
(90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
8	EARLIEST	2.1	76	76.6	3 - 6 YRS.
8	MOST LIKELY	2.9	78	80.5	6½ - 10½ YRS.
8	NOT LATER THAN	3.9	82	84.5	10 - 15 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
7	LOWER LIMIT	4.7	5 M	4.59M	1.15 - 8.04
7	UPPER LIMIT	11.8	10 M	12.56M	3.89 - 21.23

IIID Sub-Technology: In-Bottom Construction

Objective: To develop the technologies and techniques to construct an in-bottom habitat consisting of a vertical shaft beginning at the bottom of the ocean at a depth of at least 8,000 ft, and extending downward hundreds of feet joining a horizontal tunnel complex which extends from dry land under the seafloor. The technologies required are as follows:

- Vertical drilling
- Tunneling
- Inside-Out Drilling
- Rock and Muck Removal
- Formation Probing

Events IIID01 - IIID05 address this objective.

DOT ASSESSMENT RESULTS

EVENT: IIID01

A vertical drilling machine, capable of cutting a vertical shaft 10 ft in diameter, 300 ft deep, under 8,000 ft of water, in a competent rock formation; remove all rock and muck, construct a lock, and dewater the shaft.

SYSTEM CRITICALITY

N° 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	8		22 %	
DESIRABLE	4		56 %	DESIRABLE
UNNECESSARY		12	22 %	

DEGREE OF RISK

N° 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL			0 %	
.7 SIMULATION			11 %	
.9 UNPROVEN			89 %	.9

DESIRED COURSE OF ACTION

N° 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			11 %	
MEDIUM			11 %	
LONG	11		67 %	LONG
UNDESIRABLE		11	11 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
8	EARLIEST	3.3	80,85	80.1	6 - 10½ YRS
8	MOST LIKELY	3.9	90	85.9	11 - 16½ YRS
7	NOT LATER THAN	7.8	95	92.9	15 - 26½ YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
6	LOWER LIMIT	4.7	5 M	5.08 M	1.24 - 8.93
6	UPPER LIMIT	9.9	10,20 M	16.67 M	8.56 - 24.78

DOT ASSESSMENT RESULTS

EVENT: IIID02

A tunneling machine capable of cutting a horizontal tunnel complex (10 ft in diameter) in competent rock, and join this complex with a vertical shaft ... same as IIID01 ...

SYSTEM CRITICALITY

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	8		22 %	
DESIRABLE	4		56 %	DESIRABLE
UNNECESSARY		12	22 %	

DEGREE OF RISK

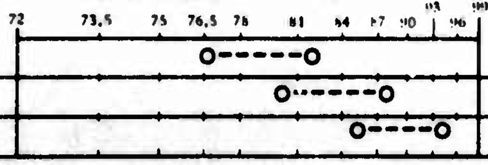
N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			22 %	
.4 EXPERIMENTAL			0 %	
.7 SIMULATION			11 %	
.9 UNPROVEN			67 %	.9

DESIRED COURSE OF ACTION

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			22 %	
MEDIUM		11	22 %	
LONG	22		45 %	LONG
UNDESIRABLE		11	11 %	

PROBABLE TIMING

CALENDAR YEARS
(90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
8	EARLIEST	4.1	80	79.0	4½ - 9½ YRS
8	MOST LIKELY	5.4	90	84.25	8½ - 16 YRS
8	NOT LATER THAN	6.4	95	89.7	13 - 22½ YRS

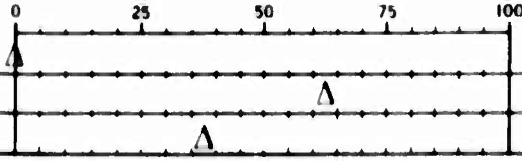
ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
6	LOWER LIMIT	1.7	1.5 M	2.58 M	1.15 - 4.02
6	UPPER LIMIT	5.6	10 M	9.50 M	4.90 - 14.10

DOT ASSESSMENT RESULTS

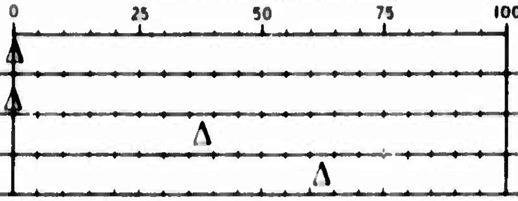
EVENT:	IIID03	An inside-out driller capable of machine cutting a large opening from a one-atmosphere environment of an in-bottom facility through the seafloor at ocean depths down to 8,000 ft.

SYSTEM CRITICALITY



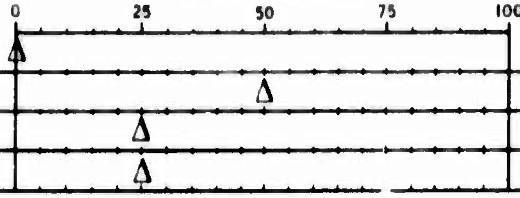
	PERCENTAGE		FINAL CONSENSUS %	CONCLUSION
N• 8	LOSS	GAIN		
ESSENTIAL			0 %	
DESIRABLE	15.5		62.5 %	DESIRABLE
UNNECESSARY		15.5	37.5 %	

DEGREE OF RISK



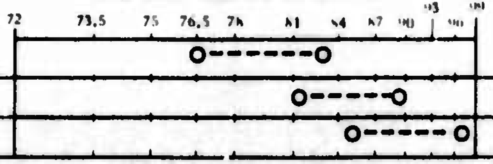
	PERCENTAGE		FINAL CONSENSUS %	CONCLUSION
N• 8	LOSS	GAIN		
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL			0 %	
.7 SIMULATION		12.5	37.5 %	
.9 UNPROVEN	12.5		62.5 %	.9

DESIRED COURSE OF ACTION



	PERCENTAGE		FINAL CONSENSUS %	CONCLUSION
N• 8	LOSS	GAIN		
SHORT RANGE GOAL			0 %	
MEDIUM		12.5	50 %	MEDIUM
LONG	25		25 %	
UNDESIRABLE		12.5	25 %	

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
6	EARLIEST	4.8	80	80.0	4 - 12 YRS
6	MOST LIKELY	5.4	None	85.5	9 - 18 YRS
5	NOT LATER THAN	5.9	None	90.6	13 - 24 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
3	LOWER LIMIT	6.6	1 M	5.67M	0 - 16.79
3	UPPER LIMIT	17.8	None M	25.00M	0 - 55.00

DOT ASSESSMENT RESULTS

EVENT: IIID04

A formation prober capable of exploring rock masses lying ahead of an excavation machine and can remotely determine the geological and engineering characteristics of the ahead formation, and is capable of functioning in ocean depths to 8,000 ft.

SYSTEM CRITICALITY

N = 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	9		11 %	
DESIRABLE		9	89 %	DESIRABLE
UNNECESSARY			0 %	

DEGREE OF RISK

N = 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL	10		0 %	
.7 SIMULATION		14	44 %	
.9 UNPROVEN	4		56 %	.9

DESIRED COURSE OF ACTION

N = 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			0 %	
MEDIUM	4		56 %	MEDIUM
LONG		4	44 %	
UNDESIRABLE			0 %	

PROBABLE TIMING

CALENDAR YEARS
(90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	3.2	78	79.6	5½ - 9½ YRS.
9	MOST LIKELY	4.0	90	84.9	10½ - 15½ YRS.
8	NOT LATER THAN	4.8	85,90	90.0	14½ - 21 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS ($ MILLONS) (90% CONFIDENCE INTERVAL)
7	LOWER LIMIT	8.2	1 M	5.07M	0 - 10.98
7	UPPER LIMIT	15.5	10 M	12.93M	1.56 - 24.29

DOT ASSESSMENT RESULTS

EVENT: IIID05 A rock and muck removal system capable of removing rock and muck from a one-atmosphere in-bottom tunneling operation into the ambient environment at ocean depths of 8,000 ft.

SYSTEM CRITICALITY

N = 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL		1	11 %	
DESIRABLE	3		67 %	DESIRABLE
UNNECESSARY		2	22 %	

DEGREE OF RISK

N = 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL		11	11 %	
.7 SIMULATION			22 %	
.9 UNPROVEN	11		67 %	.9

DESIRED COURSE OF ACTION

N = 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			11 %	
MEDIUM			45 %	MEDIUM
LONG	11		22 %	
UNDESIRABLE		11	22 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
7	EARLIEST	5.4	75	79.6	3½ - 11½ YRS
7	MOST LIKELY	6.4	80	84.6	8 - 17½ YRS
6	NOT LATER THAN	6.5	85	88.7	11½ - 22 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
5	LOWER LIMIT	1.9	5 M	3.40M	1.53 - 5.27
5	UPPER LIMIT	6.1	15 M	12.40M	6.60 - 18.20

APPENDIX D

TECHNOLOGY AREA IV. POWER SOURCES, CONVERSION, AND TRANSMISSION

SUB-TECHNOLOGY AREAS:

A. Power Sources

B. Electrical Transmission and Conditioning Equipment for Deep Submergence Vehicles

C. Transmission and Conditioning Equipment for Deep Ocean Fixed Installations

IVA Sub-Technology: Power Sources

Objective: To develop bottom supported power facilities with a capacity of 100 to 300 kw to provide power for such bottom operations as seafloor construction, active acoustic array, etc.

NOTE: Nuclear and isotope power sources are not considered.

Events IVB01 - IVB08 address this objective.

DOT ASSESSMENT RESULTS

EVENT: IVA01

A one-atmosphere, bottom-supported, thermochemical power system using hydrocarbon/oxidizer fuel (e.g., diesel oil-hydrogen peroxide) capable of driving generators producing 100 to 300 kw of electrical power in ambient conditions at 8,000-ft ocean depths. The system can operate for up to 1 month self-sustained with unattended operation.

SYSTEM CRITICALITY

N 19	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL		0.5	Δ	10.5 %	
DESIRABLE	6		Δ	79 %	DESIRABLE
UNNECESSARY		5.5	Δ	10.5 %	

DEGREE OF RISK

N 19	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE	5		Δ	5 %	
.4 EXPERIMENTAL	34		Δ	26 %	
.7 SIMULATION		33	Δ	58 %	.7
.9 UNPROVEN		6	Δ	11 %	

DESIRED COURSE OF ACTION

N 19	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL	9		Δ	26 %	
MEDIUM		3	Δ	63 %	MEDIUM
LONG			Δ	0 %	
UNDESIRABLE		6	Δ	11 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
18	EARLIEST	oo	1.1	75	75.4	3 - 4 YRS
18	MOST LIKELY	o-o	1.4	78	77.7	5 - 6 YRS
18	NOT LATER THAN	o-o	1.4	80	80.6	8 - 9 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
18	LOWER LIMIT	6.6	5 M	5.99 M	3.28 - 8.71
18	UPPER LIMIT	14.2	15 M	14.78M	8.94 - 20.62

DOT ASSESSMENT RESULTS

EVENT: IVA02 A one-atmosphere, bottom-supported, thermochemical power system using exotic fuel/oxidizer (e.g., hydrozine-hydrogen peroxide, metal slurry-oxidant), capable of driving...same as IVA01.

SYSTEM CRITICALITY

N= 19	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL				0 %	
DESIRABLE				79 %	DESIRABLE
UNNECESSARY				21 %	

DEGREE OF RISK

N= 19	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE				0 %	
.4 EXPERIMENTAL	5			16 %	
.7 SIMULATION				68 %	.7
.9 UNPROVEN		5		16 %	

DESIRED COURSE OF ACTION

N= 17	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL				0 %	
MEDIUM		6		82 %	MEDIUM
LONG	12			6 %	
UNDESIRABLE		6		12 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL)	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
18	EARLIEST		.9	76	76.3	4 - 4 1/2 YRS
18	MOST LIKELY		1.3	80	79.3	6 1/2 - 8 YRS
18	NOT LATER THAN		2.2	85	82.9	10 - 12 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
18	LOWER LIMIT	7.3	5,10 M	8.17 M	5.15 - 11.18
18	UPPER LIMIT	14.2	15 M	21.56M	15.72 - 27.39

DOT ASSESSMENT RESULTS

EVENT: IVA03 A one-atmosphere, bottom-supported fuel cell power system (e.g., hydrogen/oxygen) capable of driving... same as IVA01.

SYSTEM CRITICALITY

N° 19	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL		0.5	Δ	10.5 %	
DESIRABLE		4	Δ	79 %	DESIRABLE
UNNECESSARY	4.5		Δ	10.5 %	

DEGREE OF RISK

N° 18	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE			Δ	11 %	
.4 EXPERIMENTAL		9	Δ	67 %	.4
.7 SIMULATION	9		Δ	17 %	
.9 UNPROVEN			Δ	5 %	

DESIRED COURSE OF ACTION

N° 17	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL			Δ	29 %	
MEDIUM	6		Δ	42 %	MEDIUM
LONG		6	Δ	29 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
17	EARLIEST	o-o	1.3	76	75.4	3 - 4 YRS.
17	MOST LIKELY	o--o	2.0	78,80	77.7	5 - 6 1/2 YRS.
17	NOT LATER THAN	o--o	3.3	82,85	80.7	7 1/2 - 10 YRS.

ESTIMATED COSTS TO ACHIEVE

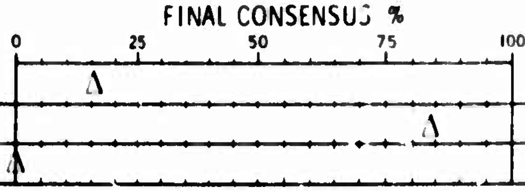
N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
17	LOWER LIMIT	5.7	8,20 M	7.97 M	5.55 - 10.39
17	UPPER LIMIT	11.6	15 M	18.68 M	13.76 - 23.60

DOT ASSESSMENT RESULTS

EVENT: IVA04 An ambient pressure, bottom-supported, fuel cell power system (e.g., hydrogen/oxygen) capable of driving... same as IVA03.

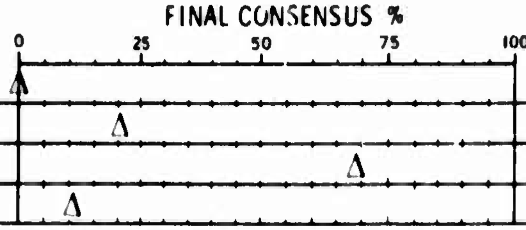
SYSTEM CRITICALITY

N 19	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	10		16 %	
DESIRABLE		15	84 %	DESIRABLE
UNNECESSARY	5		0 %	



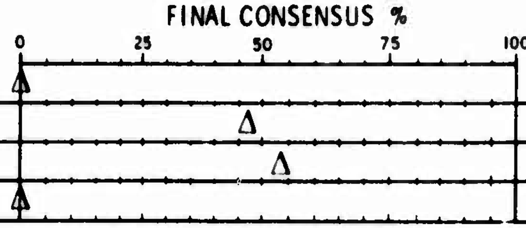
DEGREE OF RISK

N 19	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE	6		0 %	
.4 EXPERIMENTAL	1		21 %	
.7 SIMULATION		7.5	68.5 %	.7
.9 UNPROVEN	0.5		10.5 %	

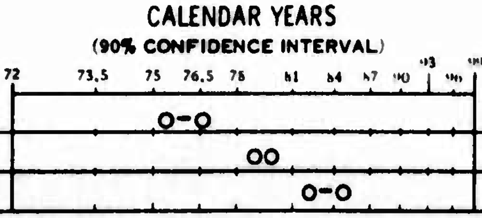


DESIRED COURSE OF ACTION

N 17	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	6		0 %	
MEDIUM		6	47 %	MEDIUM
LONG			53 %	
UNDESIRABLE			0 %	



PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
19	EARLIEST	1.5	75	76.3	3 1/2 - 5 YRS
19	MOST LIKELY	2.3	80	79.1	7 - 8 YRS
19	NOT LATER THAN	3.2	85	83.1	10 - 12 1/2 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
18	LOWER LIMIT	10.2	10 M	11.95M	7.78 - 16.13
18	UPPER LIMIT	17.3	20 M	22.68 M	15.58 - 29.78

DOT ASSESSMENT RESULTS

EVENT: IVA05 A remote control system capable of controlling a 300 kw seafloor plant (as in IVA01 thru IVA04) at 3,000-ft depths from the surface or shore via cables.

SYSTEM CRITICALITY

N· 19	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	6		26 %	
DESIRABLE		6	69 %	DESIRABLE
UNNECESSARY			5 %	

DEGREE OF RISK

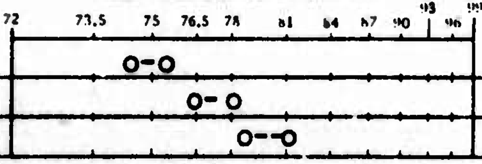
N· 19	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE	2		21 %	
.4 EXPERIMENTAL	13		5 %	
.7 SIMULATION		16	69 %	.7
.9 UNPROVEN	1		5 %	

DESIRED COURSE OF ACTION

N· 18	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	12		61 %	SHORT
MEDIUM		3	28 %	
LONG		5.5	5.5 %	
UNDESIRABLE	1.5		5.5 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
18	EARLIEST	1.3	75	75.1	2 1/2 - 3 1/2 YRS.
18	MOST LIKELY	1.9	76,80	77.2	4 1/2 - 6 YRS.
18	NOT LATER THAN	2.5	80	80.1	7 - 11 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
18	LOWER LIMIT	4.7	2 M	3.38M	1.47 - 5.28
18	UPPER LIMIT	10.5	5 M	8.28M	3.99 - 12.57

DOT ASSESSMENT RESULTS

EVENT: IVA06

An ambient pressure, bottom-supported, storage battery power system rechargeable on the seafloor with an integral battery charger and powered intermittently or continuously via cable from surface or shore utilities. The system can operate up to one year at 3,000-ft ocean depths and have an energy capacity between recharges of 2500 kwh at 5 kw.

SYSTEM CRITICALITY

N= 17	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %		CONCLUSION
ESSENTIAL		1		18 %	
DESIRABLE		10		82 %	DESIRABLE
UNNECESSARY	11			0 %	

DEGREE OF RISK

N= 16	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %		CONCLUSION
.1 PROTOTYPE	12			19 %	
.4 EXPERIMENTAL		6		69 %	.4
.7 SIMULATION		6		12 %	
.9 UNPROVEN				0 %	

DESIRED COURSE OF ACTION

N= 16	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %		CONCLUSION
SHORT RANGE GOAL		1		81 %	SHORT
MEDIUM		6		19 %	
LONG				0 %	
UNDESIRABLE	7			0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL)	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
16	EARLIEST		.8	74	74.3	2 - 2 1/2 YRS.
16	MOST LIKELY		1.0	76	76.5	4 - 5 YRS.
16	NOT LATER THAN		1.7	80	78.8	6 - 8 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
15	LOWER LIMIT	3.1	2 M	2.44 M	1.03 - 3.85
14	UPPER LIMIT	5.1	3 M	4.28 M	1.87 - 6.68

DOT ASSESSMENT RESULTS

EVENT: IVA07

An ambient pressure, bottom-supported high energy density electrochemical power system (e.g., consumable magnesium anode seawater battery, alumium-peroxide battery or hydrazine-hydrogen peroxide fuel cell) capable of providing 100 watts of power with a total energy capacity of 1000 kwh at ocean depths to 20,000 ft.

SYSTEM CRITICALITY

N· 19	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL	4		Δ	16 %	
DESIRABLE		4	Δ	74 %	DESIRABLE
UNNECESSARY			Δ	10 %	

DEGREE OF RISK

N· 18	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE	6		Δ	0 %	
.4 EXPERIMENTAL	6		Δ	22 %	
.7 SIMULATION		6	Δ	72 %	.7
.9 UNPROVEN		6	Δ	6 %	

DESIRED COURSE OF ACTION

N· 18	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL	5		Δ	17 %	
MEDIUM			Δ	67 %	MEDIUM
LONG			Δ	11 %	
UNDESIRABLE		5	Δ	5 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
18	EARLIEST	oo	.8	75	75.3	3 - 3 1/2 YRS.
18	MOST LIKELY	o-o	1.6	77	77.8	5 - 6 1/2 YRS.
18	NOT LATER THAN	o-o	2.5	80	80.9	8 - 10 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
17	LOWER LIMIT	5.1	5 M	4.52M	2.36 - 6.69
17	UPPER LIMIT	8.9	10 M	10.75M	6.98 - 14.53

DOT ASSESSMENT RESULTS

EVENT: IVA08 An ambient pressure, lithium power cell, capable of providing...same as IVA07.

SYSTEM CRITICALITY

N= 16	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL	5		Δ	19 %	
DESIRABLE		10	Δ	62 %	DESIRABLE
UNNECESSARY	5		Δ	19 %	

DEGREE OF RISK

N= 16	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL			Δ	50 %	.4
.7 SIMULATION			Δ	44 %	
.9 UNPROVEN			Δ	6 %	

DESIRED COURSE OF ACTION

N= 16	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL	7.5		Δ	12.5 %	
MEDIUM		8.5	Δ	62.5 %	MEDIUM
LONG	0.5		Δ	12.5 %	
UNDESIRABLE	0.5		Δ	12.5 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
16	EARLIEST	oo	.9	75	75.4	3 - 4 YRS
16	MOST LIKELY	o-o	1.4	78	77.8	5 - 6 1/2 YRS.
16	NOT LATER THAN	o-o	2.5	80	80.6	7 1/2 - 9 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
15	LOWER LIMIT	4.9	1 M	4.23 M	1.98 - 6.48
15	UPPER LIMIT	10.2	10 M	10.60 M	5.97 - 15.23

IVB Sub-Technology: Electrical Transmission and Conditioning Equipment for Deep Submergence Vehicles

Objective: To advance the technologies necessary for the transmission and conditioning of electrical energy required by deep submergence vehicles undergoing cyclic ambient conditions down to 20,000-ft ocean depths.

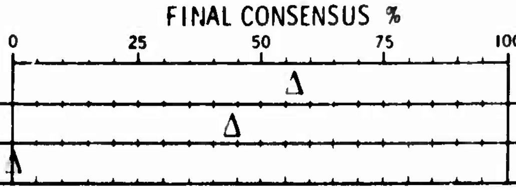
Events IVB01 - IVB24 address this objective.

DOT ASSESSMENT RESULTS

EVENT: IVB01

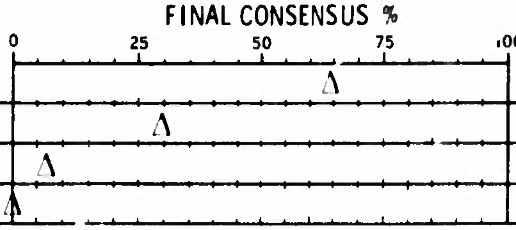
Electrical cabling capable of conducting 115 volts, 400 Hz, 150 to 200 amperes, AC, while subjected to cyclic conditions down to ocean depths of 20,000 ft. The cabling has a 0.9 probability of no failure at a 90% lower confidence limit based upon an operating period of one year at 250 operation cycles per year.

SYSTEM CRITICALITY



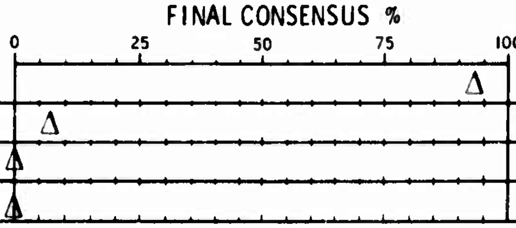
N= 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL		4	57 %	ESSENTIAL
DESIRABLE		3	43 %	
UNNECESSARY	7		0 %	

DEGREE OF RISK



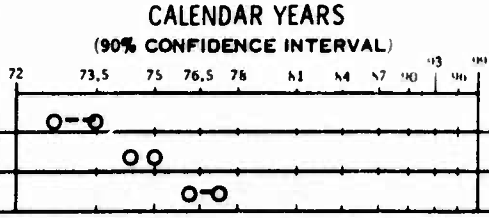
N= 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE		7	64 %	.1
.4 EXPERIMENTAL			29 %	
.7 SIMULATION			7 %	
.9 UNPROVEN	7		0 %	

DESIRED COURSE OF ACTION



N= 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			93 %	SHORT
MEDIUM			7 %	
LONG			0 %	
UNDESIRABLE			0 %	

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
14	EARLIEST	.9	73	73.1	1/2 - 1 1/2 YRS
13	MOST LIKELY	.5	78	74.8	2 1/2 - 3 YRS
13	NOT LATER THAN	.9	77	76.7	4 - 5 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
14	LOWER LIMIT	.2	.5 M	.41 M	.30 - .51
14	UPPER LIMIT	.5	1 M	.89 M	.65 - 1.13

DOT ASSESSMENT RESULTS

EVENT: IVB02 Electrical cabling capable of conducting 115 volts, 300 to 400 amperes, while subjected to...same as IVB01.

SYSTEM CRITICALITY

N= 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	6		21 %	
DESIRABLE		12	72 %	DESIRABLE
UNNECESSARY	6		7 %	

DEGREE OF RISK

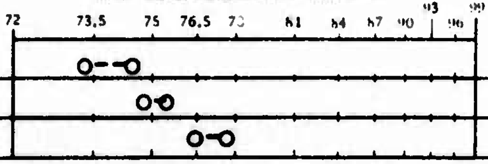
N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE		1	31 %	
.4 EXPERIMENTAL		7	61 %	.4
.7 SIMULATION			8 %	
.9 UNPROVEN	8		0 %	

DESIRED COURSE OF ACTION

N= 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			72 %	SHORT
MEDIUM		7	14 %	
LONG	7		7 %	
UNDESIRABLE			7 %	

PROBABLE TIMING

CALENDAR YEARS
(90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
13	EARLIEST	1.2	74	73.8	1 - 2 1/2 YRS.
12	MOST LIKELY	.4	75	75.1	3 - 3 1/2 YRS.
12	NOT LATER THAN	1.3	77,78	77.1	4 1/2 - 5 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

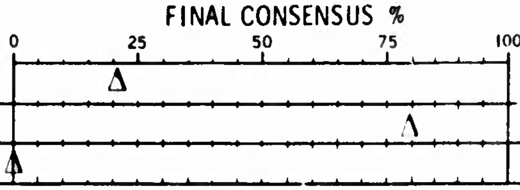
N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
13	LOWER LIMIT	.3	.5 M	.45 M	.28 - .62
13	UPPER LIMIT	.6	1 M	.96 M	.66 - 1.27

DOT ASSESSMENT RESULTS

EVENT: IVB03

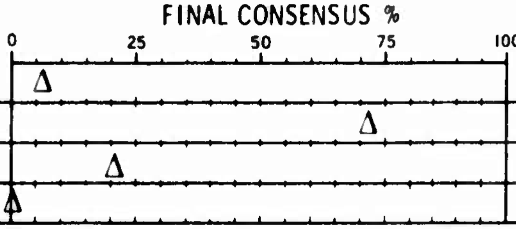
An electro-mechanical single coaxial cable, capacity 50 kva/3,000 volts, 60-400 Hz, AC, length 25,000 ft., working strength 50,000 lbs (not including cable weight). Carrier frequency 12 mHz with a 65 db maximum attenuation. The cable has a 99% reliability at a 95% lower confidence limit, based on a 10-day mission with 5 days of continuous operation at ocean depths of 25,000 ft.

SYSTEM CRITICALITY



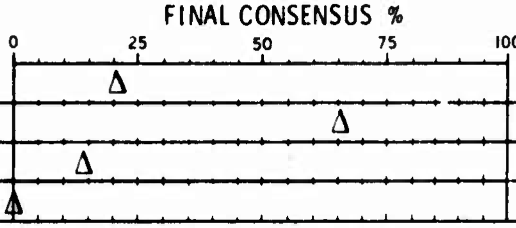
N= 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL		8	21 %	
DESIRABLE	8		79 %	DESIRABLE
UNNECESSARY			0 %	

DEGREE OF RISK



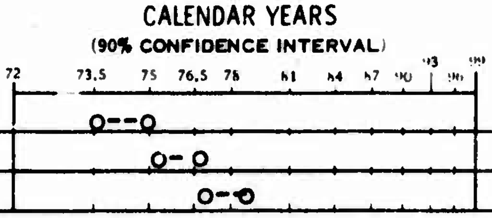
N= 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE		7	7 %	
.4 EXPERIMENTAL		12	72 %	.4
.7 SIMULATION	6		21 %	
.9 UNPROVEN	13		0 %	

DESIRED COURSE OF ACTION



N= 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		1	21 %	
MEDIUM		18	65 %	MEDIUM
LONG	19		14 %	
UNDESIRABLE			0 %	

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
14	EARLIEST	1.5	75	74.3	1 1/2 - 3 YRS.
14	MOST LIKELY	1.4	76,77	76.1	3 1/2 - 4 1/2 YRS
14	NOT LATER THAN	2.0	80	78.3	5 1/2 - 7 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
14	LOWER LIMIT	.8	1 M	1.12 M	.77 - 1.47
14	UPPER LIMIT	1.5	2,3 M	2.42 M	1.71 - 3.13

DOT ASSESSMENT RESULTS

EVENT: IVB04 Single, coaxial electrical cabling, capacity 50 kva/ 3,000 volts, AC, buoyant and flexible, carrier frequency 12 mHz with a .0026 db per ft maximum attenuation. The cable has a 99% reliability at a 95% lower confidence limit, based on a 10 day-mission with 5 days of continuous operation at ocean depths down to 25,000 ft.

SYSTEM CRITICALITY

N: 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL		1	Δ	14 %	
DESIRABLE		5	Δ	79 %	DESIRABLE
UNNECESSARY	6		Δ	7 %	

DEGREE OF RISK

N: 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL	6		Δ	21 %	
.7 SIMULATION		12	Δ	72 %	.7
.9 UNPROVEN	6		Δ	7 %	

DESIRED COURSE OF ACTION

N: 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL	7		Δ	0 %	
MEDIUM		7	Δ	50 %	MEDIUM
LONG			Δ	50 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
14	EARLIEST	o-o	1.4	75	75.6	3 - 4 YRS.
13	MOST LIKELY	o-o	1.0	77	77.2	4 1/2 - 5 1/2 YRS.
14	NOT LATER THAN	o--o	2.9	80	80.1	6 1/2 - 9 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
14	LOWER LIMIT	.6	1 M	1.04 M	.75 - 1.33
14	UPPER LIMIT	1.4	2 M	2.07 M	1.42 - 2.72

DOT ASSESSMENT RESULTS

EVENT: IVB05 An operational undersea electrical connector with both in-air and underwater make/break capability (dead cable) for use on 115 volts, 150 to 200 amps, 400 Hz systems. The connector has a 0.9 probability of failure free operation for one year at a lower confidence limit of 90% based upon 250 immersion cycles to 20,000 ft.

SYSTEM CRITICALITY

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL	12		Δ	47 %	
DESIRABLE		12	Δ	53 %	DESIRABLE
UNNECESSARY			Δ	0 %	

DEGREE OF RISK

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE	11		Δ	13 %	
.4 EXPERIMENTAL	8		Δ	27 %	
.7 SIMULATION		19	Δ	60 %	.7
.9 UNPROVEN			Δ	0 %	

DESIRED COURSE OF ACTION

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL	4		Δ	67 %	SHORT
MEDIUM		4	Δ	33 %	
LONG			Δ	0 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
15	EARLIEST	oo	.6	74	73.9	1 1/2 - 2 YRS.
15	MOST LIKELY	o-o	.5	75	75.1	3 - 3 1/2 YRS.
15	NOT LATER THAN	o-o	1.4	77	77.0	4 1/2 - 5 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
15	LOWER LIMIT	.2	.3 M	.35 M	.25 - .44
15	UPPER LIMIT	.3	1 M	.76 M	.60 - .92

DOT ASSESSMENT RESULTS

EVENT: IVB06 An operational undersea electrical connector with both in-air and underwater make/break capability (dead cable) for use on 112 volts, 300 to 400 amps, DC electrical system. The connector has a ...same as IVB05.

SYSTEM CRITICALITY

	PERCENTAGE		FINAL CONSENSUS %		
N= 15	LOSS	GAIN	0 25 50 75 100		CONCLUSION
ESSENTIAL	1		Δ	40 %	ESSENTIAL
DESIRABLE	1		Δ	40 %	DESIRABLE
UNNECESSARY		2	Δ	20 %	

DEGREE OF RISK

	PERCENTAGE		FINAL CONSENSUS %		
N= 14	LOSS	GAIN	0 25 50 75 100		CONCLUSION
.1 PROTOTYPE		1	Δ	7 %	
.4 EXPERIMENTAL		1	Δ	64 %	.4
.7 SIMULATION		4	Δ	29 %	
.9 UNPROVEN	6		Δ	0 %	

DESIRED COURSE OF ACTION

	PERCENTAGE		FINAL CONSENSUS %		
N= 15	LOSS	GAIN	0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL		8	Δ	73 %	SHORT
MEDIUM	10		Δ	13 %	
LONG		1	Δ	7 %	
UNDESIRABLE		1	Δ	7 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
14	EARLIEST	o--o	1.2	74	73.7	1 - 2 1/2 YRS.
13	MOST LIKELY	oo	.6	75	75.1	3 - 3 1/2 YRS.
14	NOT LATER THAN	o-o	1.4	76	77.1	4 1/2 - 6 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
14	LOWER LIMIT	.1	.3 M	.28 M	.22 - .34
14	UPPER LIMIT	.3	1 M	.67 M	.53 - .81

DOT ASSESSMENT RESULTS

EVENT: IVB07 Electromagnetic circuit breakers, 150 to 400 ampere (AC and/or DC) rating, capable of instantaneous and/or delayed response and providing over and under current circuit and/or remote reset and can function in ambient conditions down to ocean depths of 20,000 ft.

SYSTEM CRITICALITY

	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
N= 12	LOSS	GAIN	0 25 50 75 100		
ESSENTIAL		15		75 %	ESSENTIAL
DESIRABLE	15			25 %	
UNNECESSARY				0 %	

DEGREE OF RISK

	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
N= 12	LOSS	GAIN	0 25 50 75 100		
.1 PROTOTYPE	2			25 %	
.4 EXPERIMENTAL	2			58 %	.4
.7 SIMULATION		4		17 %	
.9 UNPROVEN				0 %	

DESIRED COURSE OF ACTION

	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
N= 12	LOSS	GAIN	0 25 50 75 100		
SHORT RANGE GOAL	3			83 %	SHORT
MEDIUM		3		17 %	
LONG				0 %	
UNDESIRABLE				0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST		1.3	74	73.4	1 - 2 YRS.
11	MOST LIKELY		.6	75	75.1	2 1/2 - 3 1/2 YRS
11	NOT LATER THAN		1.3	76	76.9	4 - 5 1/2 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
12	LOWER LIMIT	.3	.3 M	.29 M	.16 - .41
12	UPPER LIMIT	.3	.5 M	.54 M	.42 - .67

DOT ASSESSMENT RESULTS

EVENT: IVB08 Hydraulic magnetic circuit breakers...same as IVB07.

SYSTEM CRITICALITY

N= 13	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
ESSENTIAL		10	Δ	23 %	
DESIRABLE	12		Δ	15 %	
UNNECESSARY		2	Δ	62 %	UNNECESSARY

DEGREE OF RISK

N= 10	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
.1 PROTOTYPE		61	Δ	70 %	.1
.4 EXPERIMENTAL	35		Δ	20 %	
.7 SIMULATION	17		Δ	10 %	
.9 UNPROVEN	9		Δ	0 %	

DESIRED COURSE OF ACTION

N= 12	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
SHORT RANGE GOAL	6		Δ	17 %	
MEDIUM	6		Δ	25 %	
LONG	7		Δ	8 %	
UNDESIRABLE		19	Δ	50 %	UNDESIRABLE

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	o---o	1.4	74	73.8	1 - 2 1/2 YRS
9	MOST LIKELY	o--o	1.3	75	75.6	3 - 4 1/2 YRS
9	NOT LATER THAN	o--o	1.8	76	77.3	4 - 6 1/2 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	.1	.3 M	.29 M	.20 - .37
10	UPPER LIMIT	.2	.5 M	.58 M	.46 - .70

DOT ASSESSMENT RESULTS

EVENT: IVB09 Fuses, 50 to 150 ampere (AC and/or DC), capable of circuit interruption at the designed overcurrent while subjected to ambient conditions of 0° to 50°C and 0 to 13,000 psi.

SYSTEM CRITICALITY

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL		18	Δ	62 %	ESSENTIAL
DESIRABLE	2		Δ	23 %	
UNNECESSARY	16		Δ	15 %	

DEGREE OF RISK

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE	14		Δ	17 %	
.4 EXPERIMENTAL		14	Δ	75 %	.4
.7 SIMULATION			Δ	0 %	
.9 UNPROVEN			Δ	8 %	

DESIRED COURSE OF ACTION

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL		7	Δ	92 %	SHORT
MEDIUM		8	Δ	8 %	
LONG			Δ	0 %	
UNDESIRABLE	15		Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	o--o	1.2	74	73.3	1/2 - 2 YRS.
12	MOST LIKELY	o-o	1.1	75	74.7	2 - 3 YRS.
12	NOT LATER THAN	o--o	1.7	76	76.2	3 1/2 - 5 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
12	LOWER LIMIT	.1	.1 M	.15 M	.11 - .20
12	UPPER LIMIT	.1	.3 M	.33 M	.26 - .40

DOT ASSESSMENT RESULTS

EVENT: IVB10 A solid state 50 to 150 ampere circuit protection device capable of...same as IVB09.

SYSTEM CRITICALITY

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL		2	59 %	ESSENTIAL
DESIRABLE	3		33 %	
UNNECESSARY		1	8 %	

DEGREE OF RISK

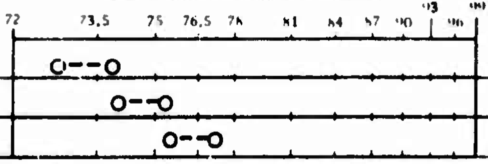
N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE		3	18 %	
.4 EXPERIMENTAL	4		73 %	.4
.7 SIMULATION			0 %	
.9 UNPROVEN		1	9 %	

DESIRED COURSE OF ACTION

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		6	91 %	SHORT
MEDIUM	6		9 %	
LONG			0 %	
UNDESIRABLE			0 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	1.1	73,74	73.2	1/2 - 2 YRS
11	MOST LIKELY	1.1	75	74.7	2 - 3 1/2 YRS
11	NOT LATER THAN	1.5	75	76.5	3 1/2 - 5 1/2 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	.1	.1 M	.21 M	.15 - .28
11	UPPER LIMIT	.1	.5 M	.50 M	.43 - .57

DOT ASSESSMENT RESULTS

EVENT:	IVB11	A 1/2 inch, 20-wire through-hull penetrator, cross-talk free, with a 25 ampere total capacity capable of functioning in 20,000 ft ocean depths.

SYSTEM CRITICALITY

N° 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL		3	Δ	43 %	
DESIRABLE		3	Δ	50 %	DESIRABLE
UNNECESSARY	6		Δ	7 %	

DEGREE OF RISK

N° 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE			Δ	8 %	
.4 EXPERIMENTAL	1		Δ	76 %	.4
.7 SIMULATION	7		Δ	8 %	
.9 UNPROVEN		8	Δ	8 %	

DESIRED COURSE OF ACTION

N° 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL		15	Δ	69 %	SHORT
MEDIUM	7		Δ	23 %	
LONG			Δ	8 %	
UNDESIRABLE	8		Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	○-○	.4	74	73.9	1 1/2 - 2 YRS
12	MOST LIKELY	○ ○	.6	75	75.3	3 - 3 1/2 YRS
12	NOT LATER THAN	○-○	1.3	76	76.6	4 - 5 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
13	LOWER LIMIT	.1	.2 M	.20 M	.16 - .23
13	UPPER LIMIT	.1	.5 M	.42 M	.36 - .48

DOT ASSESSMENT RESULTS

EVENT: IVB12 A 1 1/2 inch, 84-wire through-hull penetrator...same as IVB11.

SYSTEM CRITICALITY

N= 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	6		14 %	
DESIRABLE		6	79 %	DESIRABLE
UNNECESSARY			7 %	

DEGREE OF RISK

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE	8		0 %	
.4 EXPERIMENTAL		2	69 %	.4
.7 SIMULATION	2		23 %	
.9 UNPROVEN		8	8 %	

DESIRED COURSE OF ACTION

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			15 %	
MEDIUM			77 %	MEDIUM
LONG			8 %	
UNDESIRABLE			0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL)	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	o-o	.6	74	74.3	2 - 2 1/2 YRS
12	MOST LIKELY	oo	.6	75	75.5	3 - 4 YRS
12	NOT LATER THAN	o-o	1.4	76,78	77.3	4 1/2 - 6 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
13	LOWER LIMIT	.1	.4 M	.25 M	.19 - .31
13	UPPER LIMIT	.1	.5 M	.46 M	.39 - .54

DOT ASSESSMENT RESULTS

EVENT: IVB13 A wireless split transformer link through a pressure hull of appropriate material, without penetration, capable of transmitting 50 watts at ocean depths down to 20,000 ft.

SYSTEM CRITICALITY

N° 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL		4	25 %	
DESIRABLE			50 %	DESIRABLE
UNNECESSARY	4		25 %	

DEGREE OF RISK

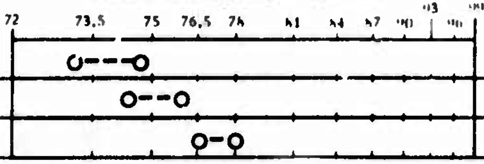
N° 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE	8		0 %	
.4 EXPERIMENTAL		2	69 %	.4
.7 SIMULATION		6	23 %	
.9 UNPROVEN			8 %	

DESIRED COURSE OF ACTION

N° 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		10	70 %	SHORT
MEDIUM		8	15 %	
LONG	13		0 %	
UNDESIRABLE	5		15 %	

PROBABLE TIMING

CALENDAR YEARS
(90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	1.5	74	73.9	1 - 2 1/2 YRS.
11	MOST LIKELY	1.5	75	75.4	2 1/2 - 4 YRS.
11	NOT LATER THAN	1.4	78	77.3	4 1/2 - 6 YRS

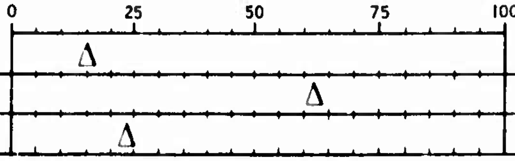
ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	.1	.1 M	.16 M	.11 - .20
11	UPPER LIMIT	.2	.6 M	.42 M	.30 - .54

DOT ASSESSMENT RESULTS

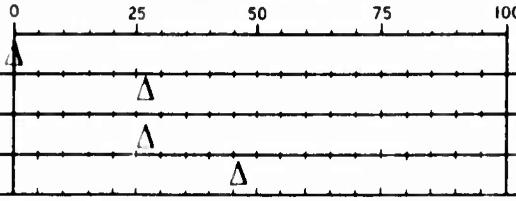
EVENT: D/B14 A wireless microwave/electrical link through a pressure hull of appropriate material, without penetration capable of transmitting 50 watts at ocean depths down to 20,000 ft.

SYSTEM CRITICALITY



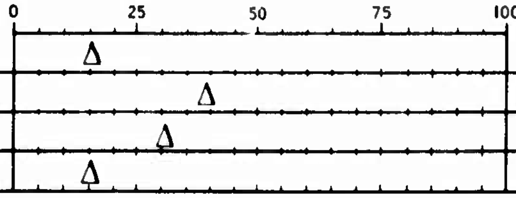
N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL		1	15 %	
DESIRABLE		12	62 %	DESIRABLE
UNNECESSARY	13		23 %	

DEGREE OF RISK



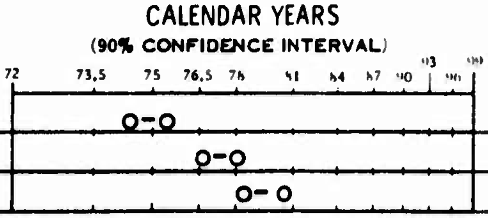
N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL		2	27 %	
.7 SIMULATION	6		27 %	
.9 UNPROVEN		4	46 %	.9

DESIRED COURSE OF ACTION



N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		1	15 %	
MEDIUM		3	39 %	MEDIUM
LONG		2	31 %	
UNDESIRABLE	6		15 %	

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	.9	75	75.1	2 1/2 - 3 1/2 YRS.
11	MOST LIKELY	1.3	78	77.3	4 1/2 - 6 YRS
11	NOT LATER THAN	2.0	80	79.5	6 1/2 - 8 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
12	LOWER LIMIT	.2	.3,.5 M	.32 M	.24 - .41
12	UPPER LIMIT	.3	1 M	.64 M	.48 - .80

DOT ASSESSMENT RESULTS

EVENT: IVB15 A wireless optical/electrical link (e.g., laser) through a pressure hull of appropriate material, without penetration, capable of transmitting 50 watts at ocean depths down to 20,000 ft.

SYSTEM CRITICALITY

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL		2	8 %	
DESIRABLE		2	77 %	DESIRABLE
UNNECESSARY	4		15 %	

DEGREE OF RISK

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL	13		0 %	
.7 SIMULATION	7		33 %	
.9 UNPROVEN		20	67 %	.9

DESIRED COURSE OF ACTION

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		1	8 %	
MEDIUM	3		17 %	
LONG		2	75 %	LONG
UNDESIRABLE			0 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	1.4	78	76.4	3 1/2 - 5 YRS.
12	MOST LIKELY	1.7	80	78.8	6 - 7 1/2 YRS.
12	NOT LATER THAN	2.3	80	81.5	8 1/2 - 10 1/2 YRS.

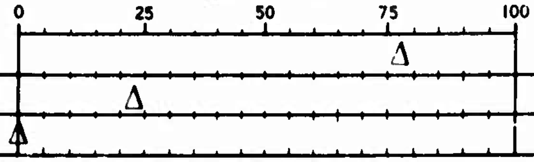
ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
12	LOWER LIMIT	.3	.3 M	.48 M	.33 - .63
12	UPPER LIMIT	.8	1.2 M	1.14 M	.73 - 1.54

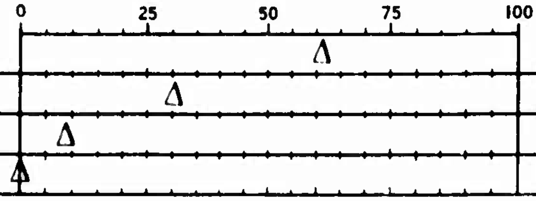
DOT ASSESSMENT RESULTS

EVENT: IVB16 Junction box, pressure compensated, with easy accessibility for maintenance, 100 ampere capacity, capable of operations at 20,000-ft ocean depths.

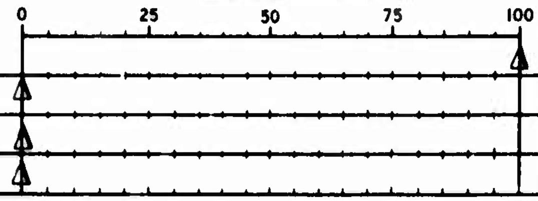
SYSTEM CRITICALITY

	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
N· 13	LOSS	GAIN	0 25 50 75 100		
ESSENTIAL		8		77 %	ESSENTIAL
DESIRABLE	8			23 %	
UNNECESSARY				0 %	

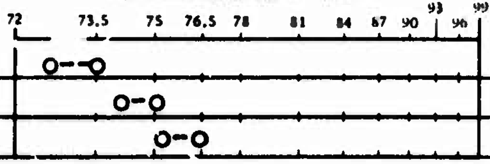
DEGREE OF RISK

	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
N· 13	LOSS	GAIN	0 25 50 75 100		
.1 PROTOTYPE		11		61 %	.1
.4 EXPERIMENTAL	6.5			31 %	
.7 SIMULATION	4.5			8 %	
.9 UNPROVEN				0 %	

DESIRED COURSE OF ACTION

	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
N· 12	LOSS	GAIN	0 25 50 75 100		
SHORT RANGE GOAL		12.5		100 %	SHORT
MEDIUM	12.5			0 %	
LONG				0 %	
UNDESIRABLE				0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL)	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
13	EARLIEST		1.0	73	73.0	1/2 - 1 1/2 YRS.
12	MOST LIKELY		.8	75	74.6	2 - 3 YRS.
12	NOT LATER THAN		1.2	76	75.9	3 1/2 - 4 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
13	LOWER LIMIT	.1	.1 M	.11 M	.8 - .15
13	UPPER LIMIT	.1	.2, .3 M	.24 M	.19 - .30

DOT ASSESSMENT RESULTS

EVENT: IVB17 Junction box, pressure compensated, with easy accessibility for maintenance, 400 ampere capacity...same as IVB16.

SYSTEM CRITICALITY

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL		8	77 %	ESSENTIAL
DESIRABLE		4	23 %	
UNNECESSARY	12		0 %	

DEGREE OF RISK

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE	9		31 %	
.4 EXPERIMENTAL		14	61 %	.4
.7 SIMULATION	5		8 %	
.9 UNPROVEN			0 %	

DESIRED COURSE OF ACTION

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		2	83 %	SHORT
MEDIUM	2		17 %	
LONG			0 %	
UNDESIRABLE			0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL)	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
13	EARLIEST		1.2	74	73.4	1 - 2 YRS.
12	MOST LIKELY		.7	75	75.0	2 1/2 - 3 1/2 YRS
12	NOT LATER THAN		1.2	76	76.3	3 1/2 - 5 YRS

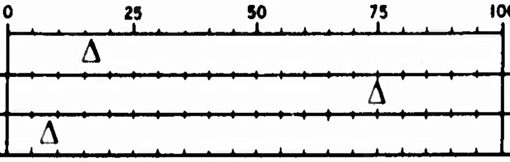
ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
13	LOWER LIMIT	.1	.1 M	.13 M	.09 - .17
13	UPPER LIMIT	.1	.2 M	.27 M	.21 - .33

DOT ASSESSMENT RESULTS

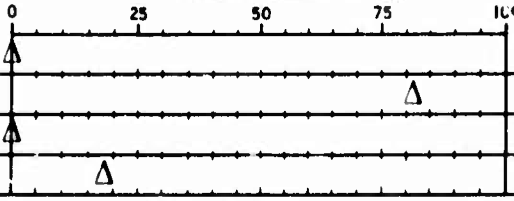
EVENT: I/B18 A solid-state inverter with no moving parts, pressure compensated, capable of producing a minimum of 150 kw, AC, at ambient conditions down to 20,000-ft ocean depths.

SYSTEM CRITICALITY



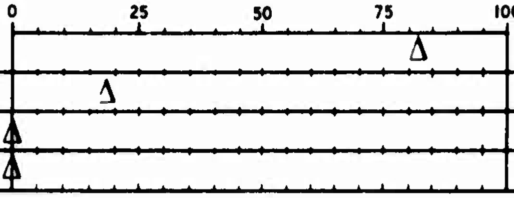
N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL		3	17 %	
DESIRABLE	4		75 %	DESIRABLE
UNNECESSARY		1	8 %	

DEGREE OF RISK



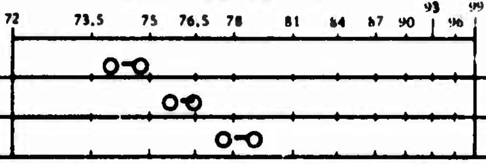
N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL		7	82 %	.4
.7 SIMULATION	8		0 %	
.9 UNPROVEN		1	18 %	

DESIRED COURSE OF ACTION



N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		7	82 %	SHORT
MEDIUM	7		18 %	
LONG			0 %	
UNDESIRABLE			0 %	

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	.6	74,75	74.4	2 - 2 1/2 YRS.
11	MOST LIKELY	.9	76	76.1	3 1/2 - 4 1/2 YRS.
11	NOT LATER THAN	1.4	78	78.3	5 1/2 - 7 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	.1	.5 M	.40 M	.34 - .45
10	UPPER LIMIT	.2	1 M	.73 M	.59 - .86

DOT ASSESSMENT RESULTS

EVENT: IVB19 An alternator, pressure compensated,...same as IVB18.

SYSTEM CRITICALITY

N° 12	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
ESSENTIAL		1	Δ	16 %	
DESIRABLE		3	Δ	42 %	DESIRABLE
UNNECESSARY	4		Δ	42 %	

DEGREE OF RISK

N° 10	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL		10	Δ	80 %	.4
.7 SIMULATION	10		Δ	0 %	
.9 UNPROVEN			Δ	20 %	

DESIRED COURSE OF ACTION

N° 10	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
SHORT RANGE GOAL		10	Δ	50 %	SHORT
MEDIUM			Δ	30 %	
LONG	10		Δ	0 %	
UNDESIRABLE			Δ	20 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	o----o	1.9	75	74.4	1 1/2 - 3 1/2 YRS.
8	MOST LIKELY	o--o	1.5	76	76.4	3 1/2 - 5 1/2 YRS.
8	NOT LATER THAN	o--o	1.6	77	77.9	5 - 7 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	.2	.2 M	.38 M	.22 - .53
9	UPPER LIMIT	.3	1 M	.81 M	.59 - 1.03

DOT ASSESSMENT RESULTS

EVENT: IVB20 An alternator, ambient pressure, seawater flooded, capable of..same as IVB18.

SYSTEM CRITICALITY

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL	8			0 %	
DESIRABLE		2		33 %	
UNNECESSARY		6		67 %	UNNECESSARY

DEGREE OF RISK

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE				0 %	
.4 EXPERIMENTAL		11		78 %	.4
.7 SIMULATION	11			0 %	
.9 UNPROVEN				22 %	

DESIRED COURSE OF ACTION

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL	8			22 %	
MEDIUM		13		33 %	
LONG	10			0 %	
UNDESIRABLE		5		45 %	UNDESIRABLE

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
8	EARLIEST		1.7	75	74.3	1 - 2 1/2 YRS.
7	MOST LIKELY		1.2	76	76.4	2 1/2 - 5 1/2 YRS.
7	NOT LATER THAN		1.3	77	78.1	5 - 7 YRS.

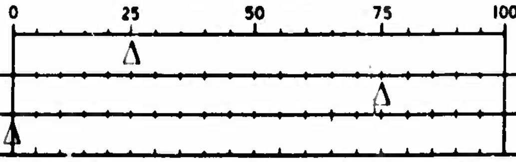
ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
8	LOWER LIMIT	.1	.5 M	.46 M	.35 - .56
8	UPPER LIMIT	.3	.8 M	.89 M	.70 - 1.07

DOT ASSESSMENT RESULTS

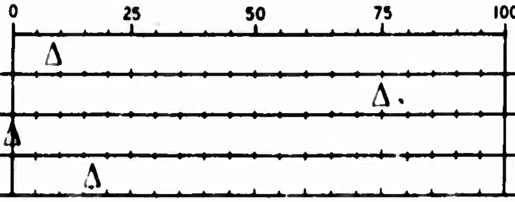
EVENT: IVB21 An AC motor controller, pressure compensated, for a 50 hp motor, capable of functioning in ambient conditions down to 20,000-ft ocean depths.

SYSTEM CRITICALITY



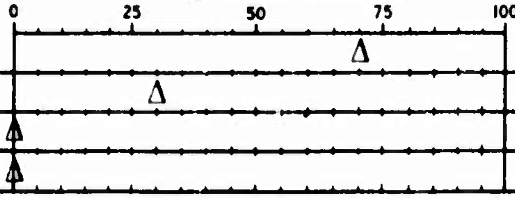
N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL		4	25 %	
DESIRABLE	4		75 %	DESIRABLE
UNNECESSARY			0 %	

DEGREE OF RISK



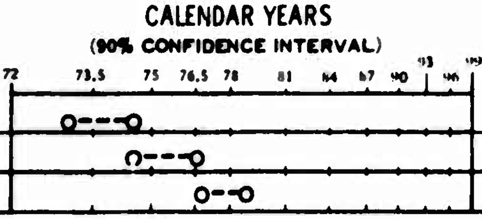
N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE	6		8 %	
.4 EXPERIMENTAL		3	75 %	.4
.7 SIMULATION			0 %	
.9 UNPROVEN		3	17 %	

DESIRED COURSE OF ACTION



N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		16	70 %	SHORT
MEDIUM	16		30 %	
LONG			0 %	
UNDESIRABLE			0 %	

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	1.4	74	73.8	1 - 2 1/2 YRS.
11	MOST LIKELY	1.7	76	75.5	2 1/2 - 4 1/2 YRS.
11	NOT LATER THAN	1.6	78	77.5	4 1/2 - 6 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
12	LOWER LIMIT	.2	.2 M	.34 M	.24 - .44
12	UPPER LIMIT	.3	.5 M	.71 M	.53 - .89

DOT ASSESSMENT RESULTS

EVENT: IVB22 An AC motor controller, ambient pressure, seawater flooded for a 50 hp motor...same as IVB21.

SYSTEM CRITICALITY

N· 12	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
ESSENTIAL		2	Δ	17 %	
DESIRABLE	4		Δ	66 %	DESIRABLE
UNNECESSARY		2	Δ	17 %	

DEGREE OF RISK

N· 12	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
.1 PROTOTYPE	7		Δ	8 %	
.4 EXPERIMENTAL	6		Δ	33 %	
.7 SIMULATION		11	Δ	42 %	.7
.9 UNPROVEN		2	Δ	17 %	

DESIRED COURSE OF ACTION

N· 10	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
SHORT RANGE GOAL		14	Δ	50 %	SHORT
MEDIUM		1	Δ	20 %	
LONG	6		Δ	30 %	
UNDESIRABLE	9		Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	o--o	1.2	74	74.9	2 1/2 - 3 1/2 YRS
11	MOST LIKELY	o--o	1.7	76	76.9	4 - 6 YRS
10	NOT LATER THAN	oo	1.4	77,78	78.5	5 1/2 - 7 1/2 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	.3	.5 M	.51 M	.37 - .65
11	UPPER LIMIT	.7	1 M	1.12 M	.73 - 1.52

DOT ASSESSMENT RESULTS

EVENT· IVB23 A DC motor controller, pressure compensated, for a 50 hp motor, capable of functioning in ambient conditions down to 20,000-ft ocean depths.

SYSTEM CRITICALITY

N· 12	PERCENTAGE LOSS	 GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL		4	Δ	25 %	
DESIRABLE		3	Δ	75 %	DESIRABLE
UNNECESSARY	7		Δ	0 %	

DEGREE OF RISK

N· 12	PERCENTAGE LOSS	 GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL			Δ	83 %	.4
.7 SIMULATION			Δ	0 %	
.9 UNPROVEN			Δ	17 %	

DESIRED COURSE OF ACTION

N· 12	PERCENTAGE LOSS	 GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL		3	Δ	67 %	SHORT
MEDIUM	3		Δ	33 %	
LONG			Δ	0 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	o---o	1.4	74	73.7	1 - 2 1/2 YRS.
11	MOST LIKELY	o--o	1.5	75	75.5	2 1/2 - 4 1/2 YRS.
11	NOT LATER THAN	o--o	1.7	77,78	77.4	4 1/2 - 6 1/2 YRS.

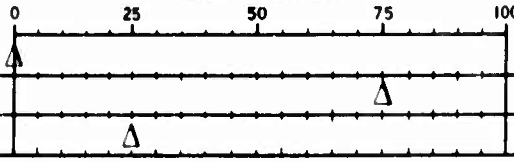
ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
12	LOWER LIMIT	.2	.2, .5 M	.38 M	.28 - .47
12	UPPER LIMIT	.3	1 M	.71 M	.58 - .85

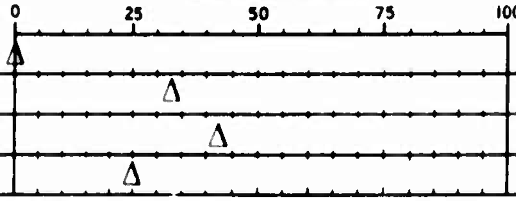
DOT ASSESSMENT RESULTS

EVENT: IVB24 A DC motor controller, ambient pressure, seawater flooded, for a 50 hp motor...same as IVB23.

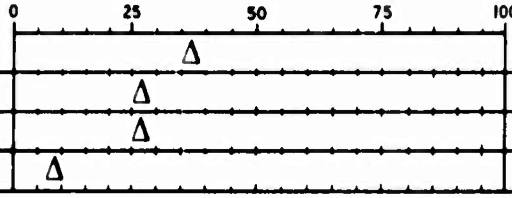
SYSTEM CRITICALITY

N· 12	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
ESSENTIAL	8			0 %	
DESIRABLE		6		75 %	DESIRABLE
UNNECESSARY		2		25 %	

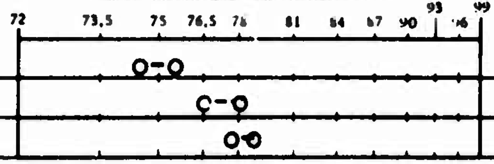
DEGREE OF RISK

N· 12	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
.1 PROTOTYPE	14			0 %	
.4 EXPERIMENTAL		4		33 %	
.7 SIMULATION		6		42 %	.7
.9 UNPROVEN		4		25 %	

DESIRED COURSE OF ACTION

N· 11	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
SHORT RANGE GOAL	9			37 %	SHORT
MEDIUM		9		27 %	
LONG				27 %	
UNDESIRABLE				9 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL)	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST		.9	75	75.1	2 1/2 - 3 1/2 YRS.
11	MOST LIKELY		1.5	76	77.3	4 1/2 - 6 YRS
10	NOT LATER THAN		1.8	78	78.6	5 1/2 - 7 1/2 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
12	LOWER LIMIT	.3	.3 M	.53 M	.34 - .72
12	UPPER LIMIT	.7	1 M	1.03 M	.65 - 1.42

IVC Sub-Technology: Transmission and Conditioning Equipment for Deep Ocean Fixed Installations

Objective: To advance the technologies necessary to transmit and condition electrical energy required by deep ocean fixed installation, at ambient conditions of 8,000 ft depths for installations with a life expectancy of up to 10 years.

Events IVC01 - IVC15 address this objective.

DOT ASSESSMENT RESULTS

EVENT: IVC01 Electrical cabling capable of conducting 480 volts, 400 Hz, 50 ampere alternating current with a 95% probability of a 10 year life at a lower confidence limit of 90% while functioning at 8,000-ft ocean depths.

SYSTEM CRITICALITY

N- 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL	2		Δ	29 %	
DESIRABLE		8	Δ	64 %	DESIRABLE
UNNECESSARY	6		Δ	7 %	

DEGREE OF RISK

N- 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE		3	Δ	33 %	
.4 EXPERIMENTAL		5	Δ	59 %	.4
.7 SIMULATION			Δ	8 %	
.9 UNPROVEN	8		Δ	0 %	

DESIRED COURSE OF ACTION

N- 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL		14	Δ	75 %	SHORT
MEDIUM	6		Δ	25 %	
LONG	8		Δ	0 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	o--o	1.3	74	73.7	1 - 2 1/2 YRS.
12	MOST LIKELY	o o	.7	75,76	75.3	3 - 3 1/2 YRS.
12	NOT LATER THAN	o-o	1.3	77	76.8	4 - 5 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
12	LOWER LIMIT	.3	.1,.5 M	.34 M	.21 - .48
12	UPPER LIMIT	.3	.5, 1 M	.73 M	.54 - .91

DOT ASSESSMENT RESULTS

EVENT: IVC02 Electrical cabling capable of conducting 15,000 volts, 400 Hz, 150 ampere alternating current with a 95% probability...same as IVC01.

SYSTEM CRITICALITY

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL		1	Δ	8 %	
DESIRABLE	10		Δ	69 %	DESIRABLE
UNNECESSARY		9	Δ	23 %	

DEGREE OF RISK

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL	21		Δ	0 %	
.7 SIMULATION		19	Δ	69 %	.7
.9 UNPROVEN		2	Δ	31 %	

DESIRED COURSE OF ACTION

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL			Δ	8 %	
MEDIUM	14		Δ	17 %	
LONG		14	Δ	75 %	LONG
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	o--o	1.6	75	75.4	2 1/2 - 4 YRS.
12	MOST LIKELY	o---o	2.5	77	77.4	4 - 6 1/2 YRS.
11	NOT LATER THAN	oo	1.3	80	79.0	6 1/2 - 7 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
12	LOWER LIMIT	.7	1 M	.87 M	.49 - 1.25
12	UPPER LIMIT	1.2	2 M	1.68 M	1.06 - 2.31

DOT ASSESSMENT RESULTS

EVENT: IVC02a Electrical cabling capable of conducting 15,000 volts, 60 Hz, ...same as IVC02.

SYSTEM CRITICALITY

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL			Δ	15 %	
DESIRABLE		7	Δ	77 %	DESIRABLE
UNNECESSARY	7		Δ	8 %	

DEGREE OF RISK

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE	9		Δ	8 %	
.4 EXPERIMENTAL	17		Δ	8 %	
.7 SIMULATION		28	Δ	69 %	.7
.9 UNPROVEN	2		Δ	15 %	

DESIRED COURSE OF ACTION

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL			Δ	9 %	
MEDIUM		9	Δ	64 %	MEDIUM
LONG	9		Δ	27 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	o--o	1.2	75	75.0	2 1/2 - 3 1/2 YRS.
12	MOST LIKELY	o---o	2.2	76,77	76.8	3 1/2 - 6 YRS.
12	NOT LATER THAN	o---o	3.5	77,80	79.5	5 1/2 - 9 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
12	LOWER LIMIT	.7	1 M	.80 M	.42 - 1.18
12	UPPER LIMIT	1.2	2 M	1.53M	.90 - 2.15

DOT ASSESSMENT RESULTS

EVENT: IVC03 Electrical cabling capable of conducting 5,000 volts, 400 Hz, 50 ampere alternating current with a 95% probability...same as IVC01.

SYSTEM CRITICALITY

N= 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL		2	21 %	
DESIRABLE		3	72 %	DESIRABLE
UNNECESSARY	5		7 %	

DEGREE OF RISK

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE	7		0 %	
.4 EXPERIMENTAL		26	69 %	.4
.7 SIMULATION	13		23 %	
.9 UNPROVEN	6		8 %	

DESIRED COURSE OF ACTION

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		1	9 %	
MEDIUM		7	91 %	MEDIUM
LONG	8		0 %	
UNDESIRABLE			0 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	.6	75	74.5	2 - 3 YRS.
12	MOST LIKELY	1.3	76	76.1	3 1/2 - 5 YRS.
12	NOT LATER THAN	2.3	77	78.3	5 - 7 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
12	LOWER LIMIT	.6	1 M	.81 M	.49 - 1.14
12	UPPER LIMIT	1.2	2 M	1.66 M	1.02 - 2.30

DOT ASSESSMENT RESULTS

EVENT: IVC03a Electrical cabling capable of conducting 5,000 volts, 60 Hz, ...same as IVC03.

SYSTEM CRITICALITY

	PERCENTAGE		FINAL CONSENSUS %		
N= 14	LOSS	GAIN	0 25 50 75 100		CONCLUSION
ESSENTIAL		1		21 %	
DESIRABLE		5		72 %	DESIRABLE
UNNECESSARY	6			7 %	

DEGREE OF RISK

	PERCENTAGE		FINAL CONSENSUS %		
N= 12	LOSS	GAIN	0 25 50 75 100		CONCLUSION
.1 PROTOTYPE		8		25 %	
.4 EXPERIMENTAL		8		50 %	.4
.7 SIMULATION	16			17 %	
.9 UNPROVEN				8 %	

DESIRED COURSE OF ACTION

	PERCENTAGE		FINAL CONSENSUS %		
N= 12	LOSS	GAIN	0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL				25 %	
MEDIUM				75 %	MEDIUM
LONG				0 %	
UNDESIRABLE				0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST		.8	74	74.1	1 1/2 - 2 1/2 YRS.
12	MOST LIKELY		.6	76	75.4	3 - 3 1/2 YRS
12	NOT LATER THAN		1.2	77	77.3	4 1/2 - 6 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
12	LOWER LIMIT	.4	.5 M	.61 M	.35 - .87
12	UPPER LIMIT	.6	1 M	1.17 M	.83 - 1.51

DOT ASSESSMENT RESULTS

EVENT: IV C04 Electrical cabling capable of conducting 480 volts, 400 Hz, 50 ampere alternating current with a 95% probability of a 10 year life at a lower confidence limit of 90% while functioning at 20,000-ft ocean depths.

SYSTEM CRITICALITY

N= 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL		1	Δ	7 %	
DESIRABLE		5	Δ	86 %	DESIRABLE
UNNECESSARY	6		Δ	7 %	

DEGREE OF RISK

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE		1	Δ	8 %	
.4 EXPERIMENTAL		9	Δ	76 %	.4
.7 SIMULATION	5		Δ	8 %	
.9 UNPROVEN	5		Δ	8 %	

DESIRED COURSE OF ACTION

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL		10	Δ	23 %	
MEDIUM	6		Δ	54 %	MEDIUM
LONG	5		Δ	15 %	
UNDESIRABLE		1	Δ	8 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
13	EARLIEST	o- o	.8	74.75	74.6	2 - 3 YRS.
12	MOST LIKELY	o-o	1.4	75	76.3	3 1/2 - 5 YRS.
13	NOT LATER THAN	o--o	2.3	77	78.7	5 1/2 - 8 YRS.

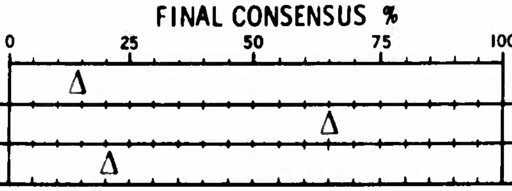
ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
13	LOWER LIMIT	.6	1 M	.85 M	.53 - 1.17
13	UPPER LIMIT	1.5	2 M	1.90 M	1.13 - 2.66

DOT ASSESSMENT RESULTS

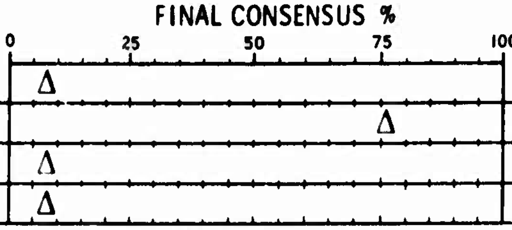
EVENT: IVC05 — Electrical cabling capable of conducting 250 volts, 400 Hz, 50 ampere direct current with a 95% probability...same as IVC04.

SYSTEM CRITICALITY



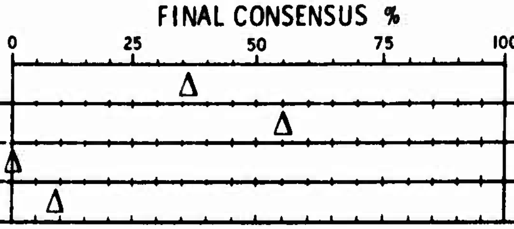
N= 14	PERCENTAGE		FINAL CONSENSUS %	CONCLUSION
	LOSS	GAIN		
ESSENTIAL		1.5	14 %	
DESIRABLE		2.5	65 %	DESIRABLE
UNNECESSARY	4		21 %	

DEGREE OF RISK



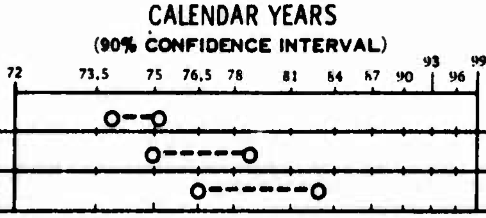
N= 12	PERCENTAGE		FINAL CONSENSUS %	CONCLUSION
	LOSS	GAIN		
.1 PROTOTYPE	5		8 %	
.4 EXPERIMENTAL		29	76 %	.4
.7 SIMULATION	12		8 %	
.9 UNPROVEN	12		8 %	

DESIRED COURSE OF ACTION



N= 11	PERCENTAGE		FINAL CONSENSUS %	CONCLUSION
	LOSS	GAIN		
SHORT RANGE GOAL		14	36 %	
MEDIUM		5	55 %	MEDIUM
LONG	14		0 %	
UNDESIRABLE	5		9 %	

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	1.3	74	74.6	2 - 3 1/2 YRS.
12	MOST LIKELY	4.0	76	77.1	3 - 7 YRS.
12	NOT LATER THAN	6.2	78	79.8	4 1/2 - 11 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
12	LOWER LIMIT	.3	.5 M	.45 M	.30 - .61
12	UPPER LIMIT	.8	.5 M	1.06 M	.66 - 1.46

DOT ASSESSMENT RESULTS

EVENT: IVC05a An electro-mechanical, multiplex, multiconductor communication cable, near neutrally buoyant, non-twisting, non-kinking, carrier frequency of 700 kHz with a maximum attenuation of 2db per 1,000-ft with a 95% probability...same as IVC04.

SYSTEM CRITICALITY

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL	8		Δ Δ	15 %	
DESIRABLE		16		70 %	DESIRABLE
UNNECESSARY	8		Δ	15 %	

DEGREE OF RISK

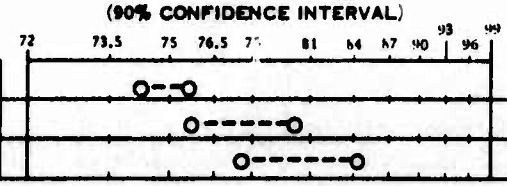
N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL		6	Δ	42 %	.4
.7 SIMULATION		6	Δ	42 %	.7
.9 UNPROVEN	12		Δ	16 %	

DESIRED COURSE OF ACTION

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL	1		Δ	17 %	
MEDIUM		12	Δ	58 %	MEDIUM
LONG	10		Δ	17 %	
UNDESIRABLE	1		Δ	8 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	1.4	74	75.0	2 1/2 - 3 1/2 YRS.
12	MOST LIKELY	4.4	76	78.1	4 - 9 1/2 YRS.
12	NOT LATER THAN	6.7	80	81.0	5 1/2 - 12 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
12	LOWER LIMIT	.7	1 M	.87 M	.73 - 1.02
12	UPPER LIMIT	1.5	1.5 M	1.95 M	1.16 - 2.73

DOT ASSESSMENT RESULTS

EVENT: IVC05b An electro-mechanical, multiplex, single coaxial communication cable...same as IVC05a.

SYSTEM CRITICALITY

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL	8		Δ	15 %	
DESIRABLE		16	Δ	70 %	DESIRABLE
UNNECESSARY	8		Δ	15 %	

DEGREE OF RISK

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL		20	Δ	75 %	.4
.7 SIMULATION	19		Δ	17 %	
.9 UNPROVEN	1		Δ	8 %	

DESIRED COURSE OF ACTION

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL	2		Δ	25 %	
MEDIUM		12	Δ	67 %	MEDIUM
LONG	9		Δ	0 %	
UNDESIRABLE	1		Δ	8 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 67 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	o-o	1.3	75	74.6	2 - 3 YRS.
12	MOST LIKELY	o-----o	4.0	76	77.3	3 - 7 1/2 YRS.
12	NOT LATER THAN	o-------o	6.4	78	80.2	5 - 11 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
12	LOWER LIMIT	.3	.5 M	.49 M	.29 - .68
12	UPPER LIMIT	2.5	.5,1 M	1.81 M	.49 - 3.13

DOT ASSESSMENT RESULTS

EVENT: IVC06 A 100 kVDC high voltage undersea long-distance high power transmission cable system with source and load terminal power conditioning equipment for bottom supported 250 kva, AC, electrical loads at 8,000-ft depths.

SYSTEM CRITICALITY

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	7		0 %	
DESIRABLE		13	92 %	DESIRABLE
UNNECESSARY	6		8 %	

DEGREE OF RISK

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL		18	75 %	.4
.7 SIMULATION	21		8 %	
.9 UNPROVEN		3	17 %	

DESIRED COURSE OF ACTION

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		1	23 %	
MEDIUM		1	8 %	
LONG	3		61 %	LONG
UNDESIRABLE		1	8 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
13	EARLIEST	.9	75	75.4	3 - 4 YRS.
13	MOST LIKELY	3.6	77	78.5	4 1/2 - 8 YRS.
13	NOT LATER THAN	6.2	80	82.0	7 - 13 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
13	LOWER LIMIT	.6	1 M	.96 M	.65 - 1.27
13	UPPER LIMIT	3.1	2 M	3.32 M	1.77 - 4.87

DOT ASSESSMENT RESULTS

EVENT: IVC07 A pressure compensated line voltage regulator and power factor correction system for insertion at intervals in long AC high-power undersea transmission cables at 8,000-ft ocean depths.

SYSTEM CRITICALITY

N= 11	PERCENTAGE LOSS	 GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL	14		Δ	9 %	
DESIRABLE		14	Δ	91 %	DESIRABLE
UNNECESSARY			Δ	0 %	

DEGREE OF RISK

N= 11	PERCENTAGE LOSS	 GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE		1	Δ	9 %	
.4 EXPERIMENTAL		4	Δ	73 %	.4
.7 SIMULATION	6		Δ	9 %	
.9 UNPROVEN		1	Δ	9 %	

DESIRED COURSE OF ACTION

N= 11	PERCENTAGE LOSS	 GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL	6		Δ	36 %	
MEDIUM	14		Δ	28 %	
LONG		20	Δ	36 %	LONG
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	o---o	1.9	75	74.7	1 1/2 - 3 1/2 YRS.
11	MOST LIKELY	o--o	2.0	75	76.6	3 1/2 - 5 1/2 YRS.
10	NOT LATER THAN	o--o	2.1	78,79	78.7	5 1/2 - 8 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	.2	.3 M	.42 M	.30 - .54
11	UPPER LIMIT	.3	.7,1 M	.78 M	.60 - .96

DOT ASSESSMENT RESULTS

EVENT: IVC08 **A fully torque-balanced, lightweight, flexible, electromechanical support cable capable of power transmissions up to 10,000 kw and supporting 50-ton submerged loads (at 8,000 ft) from a surface support platform.**

SYSTEM CRITICALITY

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL		4		31 %	
DESIRABLE		1		54 %	DESIRABLE
UNNECESSARY	5			15 %	

DEGREE OF RISK

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE				0 %	
.4 EXPERIMENTAL	3			25 %	
.7 SIMULATION		23		67 %	.7
.9 UNPROVEN	20			8 %	

DESIRED COURSE OF ACTION

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL		3		17 %	
MEDIUM		4		33 %	
LONG				50 %	LONG
UNDESIRABLE	7			0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST		.9	75	75.1	2 1/2 - 3 1/2 YRS.
12	MOST LIKELY		1.5	78	77.3	4 1/2 - 6 YRS.
12	NOT LATER THAN		2.7	80	79.9	6 1/2 - 9 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
12	LOWER LIMIT	.5	1,5 M	.71 M	.45 - .97
12	UPPER LIMIT	1,3	1 M	1.68 M	1.01 - 2.35

DOT ASSESSMENT RESULTS

EVENT: IVC09 Buoyant or neutrally buoyant electrical cabling capable of power transmission up to 10,000 kw in ocean depths down to 8,000 ft.

SYSTEM CRITICALITY

N- 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL	7			0 %	
DESIRABLE		6		92 %	DESIRABLE
UNNECESSARY		1		8 %	

DEGREE OF RISK

N- 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE				0 %	
.4 EXPERIMENTAL	13			0 %	
.7 SIMULATION		18		92 %	.7
.9 UNPROVEN	5			8 %	

DESIRED COURSE OF ACTION

N- 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL				0 %	
MEDIUM	2			38 %	
LONG		2		62 %	LONG
UNDESIRABLE				0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
13	EARLIEST		.4	75	75.0	3 - 3 YRS.
13	MOST LIKELY		1.1	77	77.2	4 1/2 - 5 1/2 YRS.
13	NOT LATER THAN		2.3	80	80.5	7 1/2 - 9 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
13	LOWER LIMIT	.3	1 M	.70 M	.54 - .85
13	UPPER LIMIT	1.2	1 M	1.63 M	1.05 - 2.22

DOT ASSESSMENT RESULTS

EVENT: IVC10 A pressure compensated 200 amp battery charger system to be integrally mounted with seafloor supported storage batteries at 8,000-ft ocean depths.

SYSTEM CRITICALITY

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL		13	73 %	ESSENTIAL
DESIRABLE	2		18 %	
UNNECESSARY	11		9 %	

DEGREE OF RISK

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE	8		0 %	
.4 EXPERIMENTAL		14	64 %	.4
.7 SIMULATION	7		18 %	
.9 UNPROVEN		1	18 %	

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	1		90 %	SHORT
MEDIUM		1	10 %	
LONG			0 %	
UNDESIRABLE			0 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	1.4	74	73.9	1 - 2 1/2 YRS.
10	MOST LIKELY	1.0	75	75.7	3 - 4 1/2 YRS.
10	NOT LATER THAN	1.5	76	77.3	4 1/2 - 6 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	.1	.5 M	.39 M	.33 - .45
10	UPPER LIMIT	.4	1 M	.88 M	.62 - 1.13

DOT ASSESSMENT RESULTS

EVENT: IVC11 A pressure compensated power line/multiplex decoupling-cricuit to isolate control signals carried on high voltage (5,000 volt) high current (50 amp) power cable functioning in ambient conditions at 8,000-ft ocean depths.

SYSTEM CRITICALITY

N· 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL		9	Δ	55 %	ESSENTIAL
DESIRABLE	10		Δ	36 %	
UNNECESSARY		1	Δ	9 %	

DEGREE OF RISK

N· 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE		1	Δ	10 %	
.4 EXPERIMENTAL	6		Δ	30 %	
.7 SIMULATION		5	Δ	60 %	.7
.9 UNPROVEN			Δ	0 %	

DESIRED COURSE OF ACTION

N· 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL		3	Δ	70 %	SHORT
MEDIUM	3		Δ	30 %	
LONG			Δ	0 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) (72 73.5 75 76.5 78 81 84 87 90 93 96 99)	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	o--o	1.2	74	73.6	1 - 2 1/2 YRS.
10	MOST LIKELY	o--o	1.3	75,76	75.3	2 1/2 - 4 YRS.
10	NOT LATER THAN	o--o	1.7	76	77.3	4 1/2 - 6 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (80% CONFIDENCE INTERVAL)
10	LOWER LIMIT	.1	.3 M	.33 M	.23 - .42
10	UPPER LIMIT	.2	.5 M	.70 M	.58 - .81

DOT ASSESSMENT RESULTS

EVENT: IVC12 An operational undersea electrical power connector with both in-air and underwater make/break capability (dead cable) for use on 250 kw (50 ampere, 5,000 volts AC) transmission system to depths of 8,000 ft.

SYSTEM CRITICALITY

N- 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL	17		Δ	21 %	
DESIRABLE		17	Δ	79 %	DESIRABLE
UNNECESSARY			Δ	0 %	

DEGREE OF RISK

N- 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE	5.5		Δ	7 %	
.4 EXPERIMENTAL		16	Δ	72 %	.4
.7 SIMULATION		2	Δ	21 %	
.9 UNPROVEN	12.5		Δ	0 %	

DESIRED COURSE OF ACTION

N- 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL		4	Δ	77 %	SHORT
MEDIUM		2	Δ	15 %	
LONG	7		Δ	0 %	
UNDESIRABLE		1	Δ	8 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
14	EARLIEST	o-o	1.1	74	73.7	1 - 2 1/2 YRS.
13	MOST LIKELY	o-o	1.6	74,76	75.5	3 - 4 YRS.
13	NOT LATER THAN	o---o	2.7	75	77.2	4 - 6 1/2 YRS.

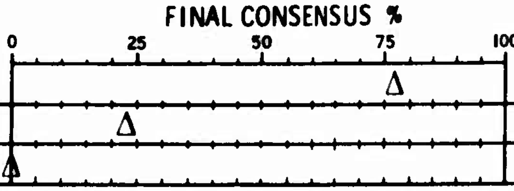
ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
14	LOWER LIMIT	.1	.4 M	.31 M	.24 - .37
14	UPPER LIMIT	.2	.6 M	.67 M	.57 - .77

DOT ASSESSMENT RESULTS

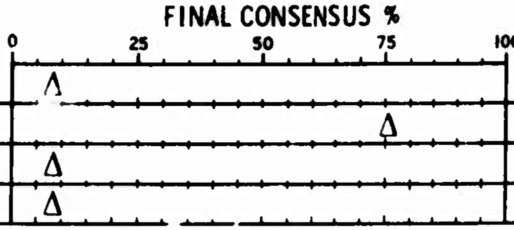
EVENT: IVC13 Circuit breakers, 500 ampere capacities, with automatic and/or remote reset, capable of functioing in ambient conditions down to ocean depths of 8,000 ft (0° to 50°C and 3600 psi).

SYSTEM CRITICALITY



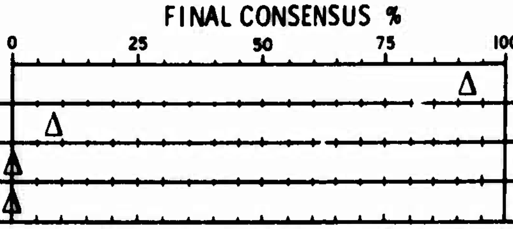
N· 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL		4	77 %	ESSENTIAL
DESIRABLE	4		23 %	
UNNECESSARY			0 %	

DEGREE OF RISK



N· 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE	5		8 %	
.4 EXPERIMENTAL		3	76 %	.4
.7 SIMULATION		1	8 %	
.9 UNPROVEN		1	8 %	

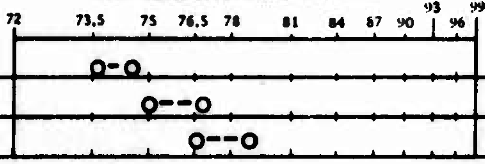
DESIRED COURSE OF ACTION



N· 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	1		92 %	SHORT
MEDIUM		1	8 %	
LONG			0 %	
UNDESIRABLE			0 %	

PROBABLE TIMING

CALENDAR YEARS
(90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
13	EARLIEST	.9	74	74.2	1 1/2 - 2 1/2 YRS.
13	MOST LIKELY	1.6	75	76.0	3 - 5 YRS.
13	NOT LATER THAN	2.5	76	77.8	4 1/2 - 7 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
13	LOWER LIMIT	.1	.2 M	.28 M	.23 - .34
13	UPPER LIMIT	.2	.5 M	.59 M	.48 - .70

DOT ASSESSMENT RESULTS

EVENT: IVC14 A transformer, pressure compensated, capable of stepping down 15,000 volts to 440 volts, 60-400 Hz, and 250 kva, in ambient conditions at ocean depths of 8,000 ft.

SYSTEM CRITICALITY

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	5		18 %	
DESIRABLE		10	64 %	DESIRABLE
UNNECESSARY	5		18 %	

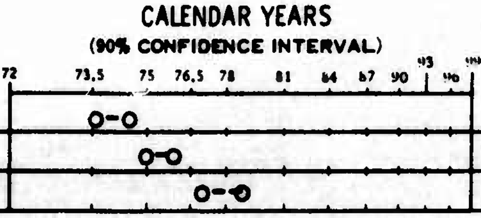
DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE	17		0 %	
.4 EXPERIMENTAL		13	80 %	.4
.7 SIMULATION		2	10 %	
.9 UNPROVEN		2	10 %	

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	2		40 %	
MEDIUM		8	50 %	MEDIUM
LONG		2	10 %	
UNDESIRABLE	8		0 %	

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	.8	75	74.1	1 1/2 - 2 1/2 YRS.
10	MOST LIKELY	.8	76	75.6	3 - 4 YRS.
10	NOT LATER THAN	1.4	78	77.9	5 - 6 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

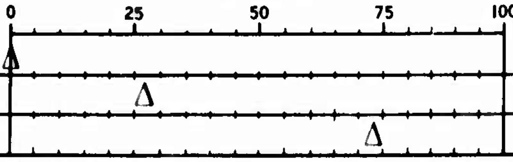
N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	.2	.3,.5 M	.46 M	.32 - .59
10	UPPER LIMIT	.7	1 M	1.01 M	.59 - 1.42

DOT ASSESSMENT RESULTS

EVENT: IVC15 A transformer, ambient pressure, seawater flooded, capable of stepping down...same as IVC14.

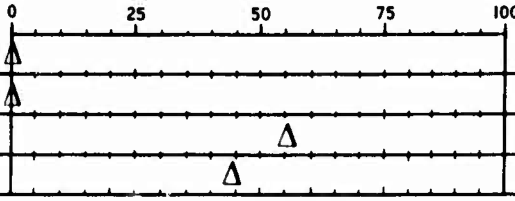
SYSTEM CRITICALITY

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	8		0 %	
DESIRABLE		4	27 %	
UNNECESSARY		4	73 %	UNNECESSARY



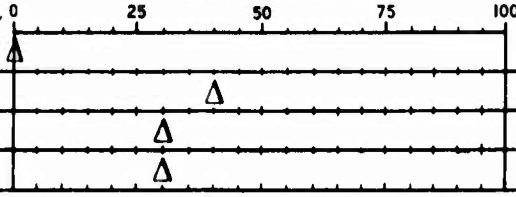
DEGREE OF RISK

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL	10		0 %	
.7 SIMULATION		11	56 %	.7
.9 UNPROVEN	1		44 %	



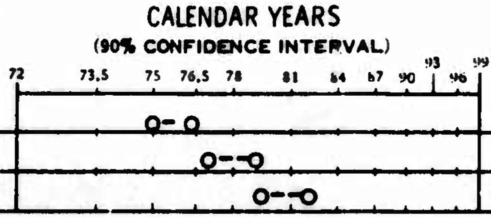
DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			0 %	
MEDIUM	6		40 %	MEDIUM
LONG		3	30 %	
UNDESIRABLE		3	30 %	



PROBABLE TIMING

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	1.0	76	75.7	3 - 4 1/2 YRS.
9	MOST LIKELY	1.5	78	78.0	5 - 7 YRS.
9	NOT LATER THAN	2.0	80	80.4	7 - 10 1/2 YRS.



ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
8	LOWER LIMIT	.5	1 M	.83 M	.47 - 1.19
8	UPPER LIMIT	1.0	2 M	1.59 M	.88 - 2.29

APPENDIX E

TECHNOLOGY AREA V. PROPULSION

SUB-TECHNOLOGY AREAS:

- A. Propulsors
- B. Power Transmission
- C. Integral Energy and Power Sources
- D. Propulsion Motors

VA Sub-Technology: Propulsors

Objective: To develop the technologies necessary to evaluate and design improved propulsors and propulsor systems for deep submergence vehicles that will provide the following:

- Greater efficiency
- Precise maneuverability in all directions
- Free of entanglement
- Minimum bottom disturbance
- Have increased reliability and maintainability
- Provide 6 degrees of motion to vessel

Events VA01 - VA04 address this objective.

DOT ASSESSMENT RESULTS

EVENT: VA01 Cycloidal propellers for systems up to 60 hp designed for submersible use at 20,000 ft. ocean depths.

SYSTEM CRITICALITY

N = 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 – 25 – 50 – 75 – 100)		CONCLUSION
ESSENTIAL	8		Δ (0)	0 %	
DESIRABLE		14	Δ (75)	75 %	DESIRABLE
UNNECESSARY	6		Δ (25)	25 %	

DEGREE OF RISK

N = 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 – 25 – 50 – 75 – 100)		CONCLUSION
.1 PROTOTYPE			Δ	8 %	
.4 EXPERIMENTAL	9		Δ	8 %	
.7 SIMULATION		9	Δ	67 %	.7
.9 UNPROVEN			Δ	17 %	

DESIRED COURSE OF ACTION

N = 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 – 25 – 50 – 75 – 100)		CONCLUSION
SHORT RANGE GOAL			Δ	17 %	
MEDIUM			Δ	50 %	MEDIUM
LONG			Δ	17 %	
UNDESIRABLE			Δ	17 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72, 73.5, 75, 76.5, 78, 81, 84, 87, 90, 93, 96, 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	o---o (73.5 – 75)	1.5	75	74.25	1½ - 3 YRS.
11	MOST LIKELY	o-o (76.5 – 78)	1.4	78	77.5	5 - 6½ YRS.
12	NOT LATER THAN	o--o (78 – 81)	2.5	80	80.1	7 - 9½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
12	LOWER LIMIT	.6	2 M	1.39 M	1.09 - 1.68
12	UPPER LIMIT	1.2	4 M	3.13 M	2.49 - 3.76

DOT ASSESSMENT RESULTS

EVENT: VA02 Variable pitch propellers for systems up to 60 hp ... same as VA01.

SYSTEM CRITICALITY

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL	6		Δ	17 %	
DESIRABLE		6	Δ	75 %	DESIRABLE
UNNECESSARY			Δ	8 %	

DEGREE OF RISK

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE			Δ	25 %	
.4 EXPERIMENTAL		17	Δ	59 %	.4
.7 SIMULATION	17		Δ	8 %	
.9 UNPROVEN			Δ	8 %	

DESIRED COURSE OF ACTION

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL		8	Δ	67 %	SHORT
MEDIUM	8		Δ	25 %	
LONG			Δ	0 %	
UNDESIRABLE			Δ	8 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	o---o	1.2	74	73.25	½ - 2 YRS.
11	MOST LIKELY	oo	.8	76	75.6	3 - 4 YRS.
12	NOT LATER THAN	o--o	2.1	80	78.25	5 - 7½ YRS.

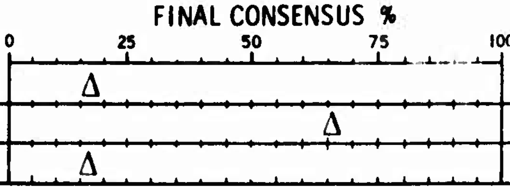
ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
12	LOWER LIMIT	.3	.5 M	.63M	.49 - .77
12	UPPER LIMIT	.7	2 M	1.75M	1.37 - 2.14

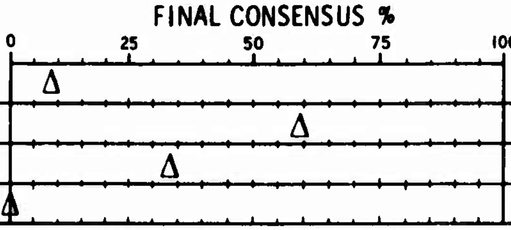
DOT ASSESSMENT RESULTS

EVENT: VA03 Waterjet propulsors for systems up to 60 hp designed for submersible use at ocean depths of 20,000 ft.

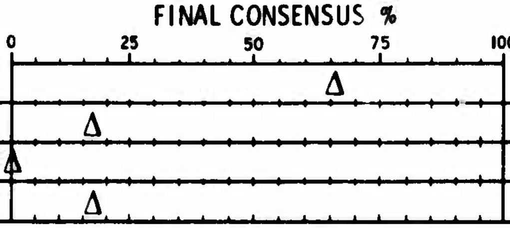
SYSTEM CRITICALITY

N= 12	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN			
ESSENTIAL	14			17 %	
DESIRABLE		28		66 %	DESIRABLE
UNNECESSARY	14			17 %	

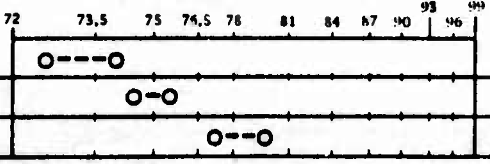
DEGREE OF RISK

N= 12	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN			
.1 PROTOTYPE	9			8 %	
.4 EXPERIMENTAL		9		59 %	.4
.7 SIMULATION				33 %	
.9 UNPROVEN				0 %	

DESIRED COURSE OF ACTION

N= 12	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN			
SHORT RANGE GOAL	1			66 %	SHORT
MEDIUM		9		17 %	
LONG				0 %	
UNDESIRABLE	8			17 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL)	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST		1.2	73	73.2	½ - 2 YRS.
11	MOST LIKELY		.9	75/76	75.4	3 - 4 YRS.
11	NOT LATER THAN		2.0	80	78.4	5½ - 7½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
12	LOWER LIMIT	.3	.5 M	.50 M	.37 - .64
12	UPPER LIMIT	.5	1.5 M	1.28 M	1.00 - 1.55

DOT ASSESSMENT RESULTS

EVENT: VA04 A tandem propeller propulsor for systems up to 60 hp designed for submersible use ... same as VA03.

SYSTEM CRITICALITY

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL			Δ	0 %	
DESIRABLE	6		Δ	25 %	
UNNECESSARY		6	Δ	75 %	UNNECESSARY

DEGREE OF RISK

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL	18		Δ	18 %	
.7 SIMULATION		18	Δ	73 %	.7
.9 UNPROVEN			Δ	9 %	

DESIRED COURSE OF ACTION

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL			Δ	8 %	
MEDIUM		8.5	Δ	33.5 %	MEDIUM
LONG	8.5		Δ	33.5 %	
UNDESIRABLE			Δ	25 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	o-o	.9	75	74.8	2½ - 3½ YRS.
11	MOST LIKELY	o---o	2.1	75	77.2	4 - 6½ YRS.
11	NOT LATER THAN	o--o	3.1	80	80.5	6½ - 10 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	.6	1/2 M	1.09M	.72 - 1.45
11	UPPER LIMIT	2.3	.5/3 M	2.95M	1.72 - 4.18

VB Sub-Technology: Power Transmission

Objective: To develop the technologies necessary to evaluate and design transmissions functioning between the motor and propulsor or motor and mechanism in the deep ocean that will improve control and performance characteristics, and where necessary, either step-up or step-down rpm.

Events VB01 - VB07 address this objective.

DOT ASSESSMENT RESULTS

EVENT: VB01 An encapsulated mechanical transmission including shaft seals capable of transmitting 40 hp at ocean depths of 20,000 ft.

SYSTEM CRITICALITY

N= 11	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
ESSENTIAL			Δ	0 %	
DESIRABLE			Δ	64 %	DESIRABLE
UNNECESSARY			Δ	36 %	

DEGREE OF RISK

N= 11	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL			Δ	27 %	
.7 SIMULATION			Δ	18 %	
.9 UNPROVEN			Δ	55 %	.9

DESIRED COURSE OF ACTION

N= 11	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
SHORT RANGE GOAL			Δ	9 %	
MEDIUM	9		Δ	55 %	MEDIUM
LONG		9	Δ	18 %	
UNDESIRABLE			Δ	18 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 67 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	oo	.6	75	74.5	2 - 3 YRS.
11	MOST LIKELY	o–o	1.2	78	76.6	4 - 5½ YRS.
11	NOT LATER THAN	oo	1.5	80	79.1	6½ - 8 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	.4	1 M	.92M	.69 - 1.15
11	UPPER LIMIT	1.1	3 M	2.58M	1.95 - 3.21

DOT ASSESSMENT RESULTS

EVENT: VB02 A non-water flooded, pressure compensated mechanical transmission with efficiencies comparable to conventional transmissions and capable of transmitting ... same as VB01.

SYSTEM CRITICALITY

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL		9	Δ	73 %	ESSENTIAL
DESIRABLE	9		Δ	18 %	
UNNECESSARY			Δ	9 %	

DEGREE OF RISK

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE			Δ	18 %	
.4 EXPERIMENTAL			Δ	18 %	
.7 SIMULATION			Δ	55 %	.7
.9 UNPROVEN			Δ	9 %	

DESIRED COURSE OF ACTION

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL		13	Δ	73 %	SHORT
MEDIUM	21		Δ	9 %	
LONG		9	Δ	9 %	
UNDESIRABLE	1		Δ	9 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	o-o	.9	74	74.0	1½ - 2½ YRS.
11	MOST LIKELY	o--o	1.4	75	75.5	3 - 4½ YRS.
11	NOT LATER THAN	o--o	2.2	80	78.1	5 - 7½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	.2	.5 M	.65M	.52 - .78
11	UPPER LIMIT	.6	2 M	1.95M	1.60 - 2.31

DOT ASSESSMENT RESULTS

EVENT: VB03 A seawater flooded mechanical transmission capable of ... same as VB01.

SYSTEM CRITICALITY

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL	9		Δ	9 %	
DESIRABLE		9	Δ	73 %	DESIRABLE
UNNECESSARY			Δ	18 %	

DEGREE OF RISK

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL			Δ	18 %	
.7 SIMULATION		9	Δ	18 %	
.9 UNPROVEN	9		Δ	64 %	.9

DESIRED COURSE OF ACTION

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL	11		Δ	9 %	
MEDIUM	4		Δ	46 %	MEDIUM
LONG		8	Δ	18 %	
UNDESIRABLE		7	Δ	27 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	o-o	.8	75	75.0	2½ - 3½ YRS.
11	MOST LIKELY	o-o	1.8	76/80	77.7	5 - 6½ YRS.
11	NOT LATER THAN	o--o	2.5	82	81.2	8 - 10½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	.8	1.5/2M	1.70M	1.27 - 2.14
11	UPPER LIMIT	1.6	3 M	3.70M	2.81 - 4.60

DOT ASSESSMENT RESULTS

EVENT: VB04 A hydraulic transmission using conventional fluids, pressure compensated capable of...same as VB01.

SYSTEM CRITICALITY

N= 11	PERCENTAGE LOSS	 GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL			Δ	27 %	
DESIRABLE			Δ	64 %	DESIRABLE
UNNECESSARY			Δ	9 %	

DEGREE OF RISK

N= 11	PERCENTAGE LOSS	 GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE	9		Δ	9 %	
.4 EXPERIMENTAL		18	Δ	73 %	.4
.7 SIMULATION	9		Δ	18 %	
.9 UNPROVEN			Δ	0 %	

DESIRED COURSE OF ACTION

N= 11	PERCENTAGE LOSS	 GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL	14		Δ	36 %	
MEDIUM		14	Δ	64 %	MEDIUM
LONG			Δ	0 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	o–o	.8	74	73.7	1½ - 2 YRS.
11	MOST LIKELY	o–o	.9	75	75.0	2½ - 3½ YRS.
11	NOT LATER THAN	o--o	1.7	78	77.4	4½ - 6½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	.3	1 M	.76 M	.60 - .92
11	UPPER LIMIT	.8	2 M	1.79 M	1.37 - 2.22

DOT ASSESSMENT RESULTS

EVENT: VB05 A hydraulic transmission using seawater at ambient conditions capable of...same as VB01.

SYSTEM CRITICALITY

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL	8		Δ	9 %	
DESIRABLE		7	Δ	73 %	DESIRABLE
UNNECESSARY		1	Δ	18 %	

DEGREE OF RISK

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE	9		Δ	0 %	
.4 EXPERIMENTAL			Δ	18 %	
.7 SIMULATION			Δ	0 %	
.9 UNPROVEN		9	Δ	82 %	.9

DESIRED COURSE OF ACTION

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL	11		Δ	9 %	
MEDIUM			Δ	0 %	
LONG		13	Δ	73 %	LONG
UNDESIRABLE	2		Δ	18 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	o--o	1.4	75	75.7	3 - 4½ YRS.
11	MOST LIKELY	o-o	2.0	77/79	78.1	5 - 7 YRS.
11	NOT LATER THAN	o--o	3.6	80	81.8	8 - 12 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	.5	2 M	1.61 M	1.30 - 1.93
11	UPPER LIMIT	1.7	5 M	3.98 M	3.05 - 4.90

DOT ASSESSMENT RESULTS

EVENT: VB06 A torque converter using conventional fluids, pressure compensated, capable of transmitting 100 hp at ocean depths of 20,000 ft.

SYSTEM CRITICALITY

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL			Δ	18 %	
DESIRABLE			Δ	73 %	DESIRABLE
UNNECESSARY			Δ	9 %	

DEGREE OF RISK

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE			Δ	9 %	
.4 EXPERIMENTAL			Δ	9 %	
.7 SIMULATION			Δ	82 %	.7
.9 UNPROVEN			Δ	0 %	

DESIRED COURSE OF ACTION

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL	1		Δ	9 %	
MEDIUM	6		Δ	64 %	MEDIUM
LONG		7	Δ	27 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	oo	1.0	75	74.4	2 - 3 YRS.
11	MOST LIKELY	o--o	2.0	77	76.8	3½ - 6 YRS.
11	NOT LATER THAN	o----o	3.2	80	79.5	7½ - 9 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	.3	1 M	.92 M	.75 - 1.10
11	UPPER LIMIT	1.1	3 M	2.70 M	2.08 - 3.33

DOT ASSESSMENT RESULTS

EVENT: VB07 A torque converter using seawater at ambient pressure capable of ...same as VB06.

SYSTEM CRITICALITY

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL			Δ	9 %	
DESIRABLE	9.5		Δ	45.5%	DESIRABLE
UNNECESSARY		9.5	Δ	45.5%	UNNECESSARY

DEGREE OF RISK

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL	1		Δ	9 %	
.7 SIMULATION	11		Δ	9 %	
.9 UNPROVEN		12	Δ	82 %	.9

DESIRED COURSE OF ACTION

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL			Δ	0 %	
MEDIUM	11		Δ	9 %	
LONG		4	Δ	64 %	LONG
UNDESIRABLE		7	Δ	27 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	o--o	1.5	75	76.1	3 - 5 YRS.
10	MOST LIKELY	o--o	2.5	77	79.0	5½ - 8½ YRS.
11	NOT LATER THAN	o-----o	4.2	80	82.6	8½ - 13 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	1.1	2 M	2.11 M	1.50 - 2.73
11	UPPER LIMIT	2.3	5 M	4.91 M	3.64 - 6.17

VC Sub-Technology: Integral Energy and Power Sources

Objective: To provide optimum energy/power sources for untethered vehicles and devices in accordance with the following:

O Increased power dentisy (power/lb, power/ft^3)
O Increased energy density (power/hr/$_{lb}$, power/hr/$_{ft}$3)
O Increased reliability and maintainability
O Increased automation
O Negligible noise and vibration

NOTE: Nuclear and isotope energy sources are not to be considered.

Events VC01 - VC06 address this objective.

DOT ASSESSMENT RESULTS

EVENT: VC01 An encapsulated thermochemical power system using hydrocarbon-oxidizer reactants (e.g., diesel oil-hydrogen peroxide) capable of a specific energy of 100 watt hrs/lb, and an energy density of 10 kilowatt hrs/ft^3. The system is capable of a 30 hour duration delivering 50 kw/unit and can operate at 20,000 ft depths.

SYSTEM CRITICALITY

N° 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL			Δ	18 %	
DESIRABLE			Δ	82 %	DESIRABLE
UNNECESSARY			Δ	0 %	

DEGREE OF RISK

N° 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL			Δ	27 %	
.7 SIMULATION		9	Δ	73 %	.7
.9 UNPROVEN	9		Δ	0 %	

DESIRED COURSE OF ACTION

N° 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL	9		Δ	64 %	SHORT
MEDIUM		18	Δ	18 %	
LONG	18		Δ	9 %	
UNDESIRABLE		9	Δ	9 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	OO	.8	75	74.5	2 - 3 YRS.
11	MOST LIKELY	O-O	1.5	78	76.9	4 - 5½ YRS
11	NOT LATER THAN	O--O	2.3	80/81	79.9	6½ - 9 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	2.2	2 M	2.85 M	1.59 - 4.11
10	UPPER LIMIT	4.0	5 M	7.00 M	4.67 - 9.33

DOT ASSESSMENT RESULTS

EVENT: VC02 An encapsulated thermochemical power system using exotic fuel-oxidizer (e.g., Hydrazine-hydrogen peroxide, Metal Slurry-Oxidant), capable of a specific energy of 500 watt hrs/lb and an energy density of 55 kw hrs/ft^3. The system ... same as VC01.

SYSTEM CRITICALITY

Nº 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %		CONCLUSION
ESSENTIAL		9	Δ	27 %	
DESIRABLE	9		Δ	55 %	DESIRABLE
UNNECESSARY			Δ	18 %	

DEGREE OF RISK

Nº 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL			Δ	18 %	
.7 SIMULATION		18	Δ	73 %	.7
.9 UNPROVEN	18		Δ	9 %	

DESIRED COURSE OF ACTION

Nº 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %		CONCLUSION
SHORT RANGE GOAL	9		Δ	0 %	
MEDIUM		9	Δ	27 %	
LONG			Δ	55 %	LONG
UNDESIRABLE			Δ	18 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL)	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	o--o	1.5	75	76.0	3 - 5 YRS.
11	MOST LIKELY	o-o	2.4	78/80	79.2	6 - 8½ YRS.
11	NOT LATER THAN	o--o	4.4	85	84.0	9½ - 14½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	3.2	2 M	4.40M	2.55 - 6.25
10	UPPER LIMIT	4.6	10 M	10.90M	8.24 - 13.60

DOT ASSESSMENT RESULTS

EVENT: VC03 An encapsulated fuel cell power system capable of a specific energy of 200 watt hrs/lb and an energy density of 10 kw hrs/ft^3. The system is capable of a 20-hour duration delivering 50 kw/unit and can operate at 20,000-ft depths, and has a system life expectancy of 2,000 hours.

SYSTEM CRITICALITY

N• 11	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
ESSENTIAL		2	Δ	27 %	
DESIRABLE		6	Δ	64 %	DESIRABLE
UNNECESSARY	8		Δ	9 %	

DEGREE OF RISK

N• 11	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL		15	Δ	73 %	.4
.7 SIMULATION	7		Δ	18 %	
.9 UNPROVEN	8		Δ	9 %	

DESIRED COURSE OF ACTION

N• 11	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
SHORT RANGE GOAL		3.5	Δ	36.5%	SHORT
MEDIUM	13.5		Δ	36.5%	
LONG		18	Δ	18 %	
UNDESIRABLE	8		Δ	9 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 73 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	OO	.7	75	74.5	2 - 3 YRS.
10	MOST LIKELY	O---O	1.7	78	77.4	4½ - 6½ YRS.
10	NOT LATER THAN	O--O	3.1	80/85	81.4	7½ - 11 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	3.1	5 M	4.85M	3.06 - 6.64
10	UPPER LIMIT	6.5	10/20M	11.20M	7.41 - 14.99

DOT ASSESSMENT RESULTS

EVENT: VC04 An ambient pressure fuel cell power system capable of a specific energy of 300 watt hrs/lb and an energy density of 18 kw hrs/ft^3. The system is capable of a 20 hour duration delivering 50 kw/unit and can operate at 20,000 ft depths, and has a system life expectancy of 9,000 hours.

SYSTEM CRITICALITY

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL			36 %	
DESIRABLE		9	64 %	DESIRABLE
UNNECESSARY	9		0 %	

DEGREE OF RISK

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL	7		9 %	
.7 SIMULATION		22	64 %	.7
.9 UNPROVEN	15		27 %	

DESIRED COURSE OF ACTION

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	7		0 %	
MEDIUM		3.5	45.5 %	MEDIUM
LONG		3.5	45.5 %	LONG
UNDESIRABLE			0 %	

PROBABLE TIMING

CALENDAR YEARS
(90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	1.4	76	76.5	$3\frac{1}{2}$ - 5 YRS.
11	MOST LIKELY	1.2	80	78.7	6 - $7\frac{1}{2}$ YRS.
11	NOT LATER THAN	2.7	81/85	83.4	10 - 13 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	5.4	3 M	6.30M	3.18 - 9.42
10	UPPER LIMIT	10.5	15 M	15.60M	9.53 - 21.67

DOT ASSESSMENT RESULTS

EVENT: VC05 A solid propellant energy source controllable and operable in ambient pressures down to 20,000 ft with a specific energy of 500 watt hrs/lb with an energy density of 60 kw hrs/ft^3 and capable of a 20-hour duration delivering 50 kw/unit.

SYSTEM CRITICALITY

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)	%	CONCLUSION
ESSENTIAL			Δ	0 %	
DESIRABLE		7	Δ	82 %	DESIRABLE
UNNECESSARY	7		Δ	18 %	

DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)	%	CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL	10		Δ	0 %	
.7 SIMULATION		10	Δ	40 %	
.9 UNPROVEN			Δ	60 %	.9

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)	%	CONCLUSION
SHORT RANGE GOAL			Δ	0 %	
MEDIUM	10		Δ	10 %	
LONG		10	Δ	80 %	LONG
UNDESIRABLE			Δ	10 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	o--o	2.1	80	77.4	4 - 6½ YRS
9	MOST LIKELY	o---o	3.1	82/85	80.4	6½ - 10½ YRS
10	NOT LATER THAN	o---o	4.2	90	85.7	11½ - 16 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	2.4	5 M	4.22M	2.71 - 5.73
9	UPPER LIMIT	7.1	10 M	11.89M	7.51 - 16.27

DOT ASSESSMENT RESULTS

EVENT: VC06 A secondary battery capable of a specific energy greater than 60 watt hrs/lb and an energy density of 7.8 kw hrs/ft^3, operable in ambient conditions for 20,000-ft ocean depths and capable of a 40-hr duration delivering 50 kw/unit, and capable of 200 charging cycles.

SYSTEM CRITICALITY

N= 11	PERCENTAGE LOSS	 GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL		2	Δ	27 %	
DESIRABLE	3		Δ	64 %	DESIRABLE
UNNECESSARY		1	Δ	9 %	

DEGREE OF RISK

N= 11	PERCENTAGE LOSS	 GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL	8		Δ	9 %	
.7 SIMULATION		16	Δ	82 %	.7
.9 UNPROVEN	8		Δ	9 %	

DESIRED COURSE OF ACTION

N= 11	PERCENTAGE LOSS	 GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL		13	Δ	55 %	SHORT
MEDIUM		3	Δ	36 %	
LONG	17		Δ	0 %	
UNDESIRABLE		1	Δ	9 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	o--o	1.1	74/76	74.8	2 - 3½ YRS.
10	MOST LIKELY	o--o	1.8	78/79	77.7	4½ - 6½ YRS.
10	NOT LATER THAN	o-o	3.3	83	81.6	7½ -11½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	1.2	3 M	1.89M	1.20 - 2.59
10	UPPER LIMIT	2.8	8 M	5.85M	4.21 - 7.49

VD Sub-Technology: Propulsion Motors

Objective: To advance the technologies necessary to develop various external (outside the pressure hull) propulsion motors thatcan be used to drive propulsors or other mechanisms with the desired performance characteristics in ambient conditions down to 20,000-ft ocean depths.

Events VD01 - VD06 address this objective.

DOT ASSESSMENT RESULTS

EVENT: VD01 A 40 hp, AC motor, ambient pressure compensated, non-water flooded capable of 500 hours unattended and 2,000-hours intermittent operation at ocean depths of 20,000 ft.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL			50 %	ESSENTIAL
DESIRABLE			50 %	DESIRABLE
UNNECESSARY			0 %	

DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE		10	30 %	
.4 EXPERIMENTAL	10		30 %	
.7 SIMULATION			40 %	.7
.9 UNPROVEN			0 %	

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	10		80 %	SHORT
MEDIUM		10	20 %	
LONG			0 %	
UNDESIRABLE			0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	o---o	1.4	73	73.5	½ - 2½ YRS.
10	MOST LIKELY	o-o	1.3	75	75.7	3 - 4½ YRS.
10	NOT LATER THAN	o--o	2.2	78	78.6	5½ - 8 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	.4	.5 M	.55 M	.32 - .77
10	UPPER LIMIT	.8	1 M	1.25 M	.80 - 1.70

DOT ASSESSMENT RESULTS

EVENT: VD02 A 40 hp, AC motor, ambient pressure, seawater flooded
... same as VD01.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL	10		Δ	10 %	
DESIRABLE		10	Δ	90 %	DESIRABLE
UNNECESSARY			Δ	0 %	

DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE		10	Δ	10 %	
.4 EXPERIMENTAL	10		Δ	30 %	
.7 SIMULATION	10		Δ	40 %	.7
.9 UNPROVEN		10	Δ	20 %	

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL		10	Δ	10 %	
MEDIUM	30		Δ	50 %	MEDIUM
LONG		20	Δ	40 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	o--o	1.1	74	74.7	2 - 3½ YRS
10	MOST LIKELY	o--o	1.8	75	76.9	4 - 6 YRS
10	NOT LATER THAN	o--o	2.3	80	80.9	7½ - 10½ YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	.7	1 M	1.21 M	.78 - 1.64
10	UPPER LIMIT	1.6	2 M	2.75 M	1.80 - 3.69

DOT ASSESSMENT RESULTS

EVENT: VD03 A 40 hp, DC motor, ambient pressure compensated, non-water flooded ... same as VD01.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	 GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL		10	Δ	60 %	ESSENTIAL
DESIRABLE			Δ	20 %	
UNNECESSARY	10		Δ	20 %	

DEGREE OF RISK

N= 10	PERCENTAGE LOSS	 GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE		10	Δ	50 %	.1
.4 EXPERIMENTAL		10	Δ	40 %	
.7 SIMULATION	20		Δ	10 %	
.9 UNPROVEN			Δ	0 %	

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	 GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL			Δ	40 %	
MEDIUM		10	Δ	60 %	MEDIUM
LONG	10		Δ	0 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	o-----o	1.4	73	73.3	½ - 2 YRS.
10	MOST LIKELY	o-o	1.2	74	75.2	2½ - 4 YRS.
10	NOT LATER THAN	o--o	1.9	80	78.4	5½ - 7½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	.6	.2 M	.67 M	.32 - 1.01
10	UPPER LIMIT	1.2	1 M	1.53 M	.82 - 2.24

DOT ASSESSMENT RESULTS

EVENT: VD04 A 40 hp, DC motor, with electronic commutation, 10 hp ambient pressure, seawater flooded ... same as VD01.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL			Δ	0 %	
DESIRABLE			Δ	100 %	DESIRABLE
UNNECESSARY			Δ	0 %	

DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL	20		Δ	10 %	
.7 SIMULATION		20	Δ	60 %	.7
.9 UNPROVEN			Δ	30 %	

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL			Δ	0 %	
MEDIUM			Δ	20 %	
LONG			Δ	80 %	LONG
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	O--O	1.0	75	74.9	2½ - 3½ YRS
10	MOST LIKELY	O-O	1.6	77	77.9	5 - 7 YRS
10	NOT LATER THAN	O---O	3.4	80	82.1	8 -- 12 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	1.1	.2 M	1.70 M	1.08 - 2.32
10	UPPER LIMIT	2.2	1 M	4.10 M	2.82 - 5.38

DOT ASSESSMENT RESULTS

EVENT: VD05 A 100 hp, DC motor, ambient pressure compensated, non-water flooded ... same as VD01.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL		10	Δ	20 %	
DESIRABLE			Δ	40 %	DESIRABLE
UNNECESSARY	10		Δ	40 %	

DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE		10	Δ	20 %	
.4 EXPERIMENTAL		10	Δ	10 %	
.7 SIMULATION	30		Δ	60 %	.7
.9 UNPROVEN		10	Δ	10 %	

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL		10	Δ	10 %	
MEDIUM	10		Δ	20 %	
LONG		10	Δ	60 %	LONG
UNDESIRABLE	10		Δ	10 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73,5 75 76,5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	o---o	1.8	75	74.6	1½ - 3½ YRS.
10	MOST LIKELY	o--o	2.2	80	77.9	4½ - 7 YRS.
10	NOT LATER THAN	o----o	3.7	80	82.0	8 - 12 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	1.0	1/2 M	1.55 M	.98 - 2.12
10	UPPER LIMIT	1.9	3 M	3.20 M	2.11 - 4.29

DOT ASSESSMENT RESULTS

EVENT: VD06 A 100 hp, DC motor, with electronic commutation, ambient pressure, seawater flooded ... same as VD01.

SYSTEM CRITICALITY

N· 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL			Δ	20 %	
DESIRABLE	20		Δ	30 %	
UNNECESSARY		20	Δ	50 %	UNNECESSARY

DEGREE OF RISK

N· 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL			Δ	0 %	
.7 SIMULATION	10		Δ	40 %	
.9 UNPROVEN		10	Δ	60 %	.9

DESIRED COURSE OF ACTION

N· 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL			Δ	0 %	
MEDIUM			Δ	0 %	
LONG	20		Δ	70 %	LONG
UNDESIRABLE		20	Δ	30 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	o-o	1.1	75	75.8	3 - 4½ YRS.
10	MOST LIKELY	o--o	2.3	80	79.7	6½ - 9 YRS.
10	NOT LATER THAN	o-o	3.2	80	83.8	10 - 13½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	1.0	2 M	3.10 M	2.49 - 3.71
10	UPPER LIMIT	2.6	5 M	6.30 M	4.79 - 7.81

APPENDIX F

TECHNOLOGY AREA VI. SURVEILLANCE AND COMMUNICATIONS

SUB-TECHNOLOGY AREAS:

A. Bottom Positioning
B. Surveillance and Viewing
C. Communications

VIA Sub-Technology: Bottom Positioning

Objective: To develop the capability to resolve a small object (5 ft in diameter) at a 20,000-ft depth for precision work employing various types of underwater work systems.

Events VIA01 - VIA02 address this objective.

DOT ASSESSMENT RESULTS

EVENT: VIA01 A surface-mounted, 3-dimensional, active acoustic system capable of locating an on-bottom or above-bottom object at least 5 ft in diameter to an accuracy of ± 200 ft in range, azimuth, and depth, at depths to 20,000 ft.

SYSTEM CRITICALITY

N= 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	6		0 %	
DESIRABLE		4	79 %	DESIRABLE
UNNECESSARY		2	21 %	

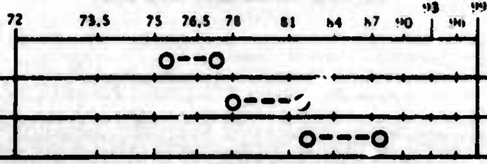
DEGREE OF RISK

N= 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL	5		7 %	
.7 SIMULATION	5		14 %	
.9 UNPROVEN		10	79 %	.9

DESIRED COURSE OF ACTION

N= 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	12.5		0 %	
MEDIUM		1.5	14 %	
LONG		9.5	72 %	LONG
UNDESIRABLE		1.5	14 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL)	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
13	EARLIEST		2.6	78	76.5	3½ - 6 YRS.
13	MOST LIKELY		4.2	75/80	80.1	6 - 10 YRS
12	NOT LATER THAN		6.2	80	85.5	10½ - 16½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
14	LOWER LIMIT	3.6	1 M	4.25M	2.56 - 5.94
14	UPPER LIMIT	15.6	5 M	14.29M	6.92 - 21.65

DOT ASSESSMENT RESULTS

EVENT: VIA02 A surface-mounted, 3-dimensional, active acoustic system employing a transponder on the submerged device, capable of locating the on-bottom or above-bottom device to an accuracy of ± 100 ft in range, azimuth, and depth, to depths of 20,000 ft.

SYSTEM CRITICALITY

N= 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL	2		Δ	64 %	ESSENTIAL
DESIRABLE		2	Δ	29 %	
UNNECESSARY			Δ	7 %	

DEGREE OF RISK

N= 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE		2	Δ	29 %	
.4 EXPERIMENTAL		2	Δ	35 %	.4
.7 SIMULATION	4		Δ	29 %	
.9 UNPROVEN			Δ	7 %	

DESIRED COURSE OF ACTION

N= 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL		7	Δ	72 %	SHORT
MEDIUM		7	Δ	14 %	
LONG	7		Δ	7 %	
UNDESIRABLE	7		Δ	7 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
13	EARLIEST	o o	.9	73/75	74.0	1½ - 2½ YRS.
12	MOST LIKELY	o--o	1.9	75	76.4	3½ - 5½ YRS.
12	NOT LATER THAN	o--o	2.6	78	78.9	5½ - 8½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
13	LOWER LIMIT	2.6	.5 M	1.66M	.37 - 2.95
13	UPPER LIMIT	12.[illegible]	1 M	6.58M	.25 - 12.91

VIB Sub-Technology: Surveillance and Viewing

Objective: To develop active/passive, acoustic and visual methods for observation, location, and tracking of static and moving objects from beneath the surface down to ocean depths of 20,000 ft.

Events VIB01 - VIB15 address this objective.

DOT ASSESSMENT RESULTS

EVENT: VIB01 A head coupled television system, using conventional underwater TV, which has a remotely controlled TV camera in a work vehicle at a 20,000 ft depth. The viewing CRT screen is mounted on the head of a surface operator and the remote TV camera moves in synchronization with the head movement of the operator. The system includes a two-way, multiplex link via a single coaxial cable between a surface control center and the remote work vehicle. The system, using conventional underwater TV has a 20-ft to 30-ft range and is used in conjunction with quartz-iodide 250 watt lamps or equivalent for illumination.

SYSTEM CRITICALITY

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL		1	Δ	8%	
DESIRABLE	5		Δ	61%	DESIRABLE
UNNECESSARY		4	Δ	31%	

DEGREE OF RISK

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL	1		Δ	46 %	.4
.7 SIMULATION	1		Δ	46 %	.7
.9 UNPROVEN		2	Δ	8 %	

DESIRED COURSE OF ACTION

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL		3	Δ	23 %	
MEDIUM	9		Δ	38 %	MEDIUM
LONG		2	Δ	8 %	
UNDESIRABLE		4	Δ	31 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	o–o	1.0	75	74.4	2 - 3 YRS.
12	MOST LIKELY	o--o	1.8	78	76.5	3½ - 5½ YRS.
12	NOT LATER THAN	o--o	2.7	80	78.8	5½ - 8 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
12	LOWER LIMIT	1.6	1 M	1.83M	.98 - 2.69
12	UPPER LIMIT	5.2	1.5/3M	5.92M	3.21 - 8.62

DOT ASSESSMENT RESULTS

EVENT: VIB02 A directional ranging sonar system with a 180-yard range and a forward field of view of 160 degrees in azimuth and 17 degrees vertical. The system has a visual display mounted on the operator's console. The system is remotely operated by a surface operator, via a transmission cable, and can function on a platform at 20,000 ft ocean depths.

SYSTEM CRITICALITY

N= 13	PERCENTAGE		FINAL CONSENSUS %	CONCLUSION
	LOSS	GAIN		
ESSENTIAL	5		8 %	
DESIRABLE		4	84 %	DESIRABLE
UNNECESSARY		1	8 %	

DEGREE OF RISK

N= 13	PERCENTAGE		FINAL CONSENSUS %	CONCLUSION
	LOSS	GAIN		
.1 PROTOTYPE		2	15 %	
.4 EXPERIMENTAL		2	62 %	.4
.7 SIMULATION	4		23 %	
.9 UNPROVEN			0 %	

DESIRED COURSE OF ACTION

N= 13	PERCENTAGE		FINAL CONSENSUS %	CONCLUSION
	LOSS	GAIN		
SHORT RANGE GOAL			54 %	SHORT
MEDIUM			31 %	
LONG			15 %	
UNDESIRABLE			0 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	.9	74	74.2	1½ - 2½ YRS.
12	MOST LIKELY	1.6	75/77	76.3	3½ - 5 YRS
12	NOT LATER THAN	1.0	80	79.2	6 - 8½ YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
13	LOWER LIMIT	.9	1 M	1.08 M	.66 - 1.51
13	UPPER LIMIT	4.5	3 M	3.95 M	1.75 - 6.16

DOT ASSESSMENT RESULTS

EVENT: VIB03 A directional passive binaural hydrophone system with a capability of positioning an 80dB sound (0.0002 microbars) up to 1,000 ft distances with a beam width of 3 degrees at approximately 10 KHz. The system is remotely operated by a surface operator via a single phase coaxial cable. The system can function on a platform at 20,000 ft ocean depths.

SYSTEM CRITICALITY

N. 13	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
ESSENTIAL	5		Δ	8 %	
DESIRABLE	1		Δ	46 %	
UNNECESSARY		6	Δ	46 %	UNNECESSARY

DEGREE OF RISK

N. 12	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
.1 PROTOTYPE	7		Δ	0 %	
.4 EXPERIMENTAL		15	Δ	58 %	.4
.7 SIMULATION	11		Δ	25 %	
.9 UNPROVEN		3	Δ	17 %	

DESIRED COURSE OF ACTION

N. 12	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
SHORT RANGE GOAL		4	Δ	25 %	
MEDIUM	12		Δ	17 %	
LONG			Δ	0 %	
UNDESIRABLE		8	Δ	58 %	UNDESIRABLE

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	o---o	2.2	74	74.8	1½ - 4 YRS.
12	MOST LIKELY	o----o	3.6	75	77.3	3½ - 7 YRS.
12	NOT LATER THAN	o----o	5.6	77	80.3	5½ - 11 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
12	LOWER LIMIT	2.2	1 M	1.73 M	.60 - 2.87
12	UPPER LIMIT	5.2	2 M	4.53 M	1.85 - 7.21

DOT ASSESSMENT RESULTS

EVENT: VIB04 A narrow field of view (FOV) TV system with FOV variable from 2.5° to 20° and having a field depth of ± 20 ft. System can resolve a 1-inch, 25% reflecting target against a black background anywhere within FOV (for FOV=5°) at a signal-to-noise ratio of unity for a target distance of up to 100 ft in water with an attenuation coefficient of .25/meter. Resolution will not be degraded by platform motions of 6 kts. System weight in water will not exceed 150 lbs and system will be capable of operation at a duty cycle of 1 for 40 hrs with a total input power of 25 kw hrs.

SYSTEM CRITICALITY

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL			8%	
DESIRABLE	2		67%	DESIRABLE
UNNECESSARY		2	25%	

DEGREE OF RISK

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE		9	17%	
.4 EXPERIMENTAL		2	25%	
.7 SIMULATION	15		8%	
.9 UNPROVEN		4	50%	.9

DESIRED COURSE OF ACTION

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		3	28%	
MEDIUM	6		36%	
LONG			0%	
UNDESIRABLE		3	36%	UNDESIRABLE

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	O-----O	2.5	75	75.5	2 - 5 YRS.
11	MOST LIKELY	O------O	5.2	77	79.4	4½ - 10 YRS.
11	NOT LATER THAN	O--------O	8.0	80	83.5	7 - 16 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	7.5	1 M	7.07M	2.99 - 11.15
11	UPPER LIMIT	17.7	3,50 M	17.77M	8.09 - 27.50

DOT ASSESSMENT RESULTS

EVENT: VIB05 Same as VIB04 except that total input power available is 30 kw and maximum range shall be 125 ft. Weight requirements will be those appropriate to towed fish or submersible.

SYSTEM CRITICALITY

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL			Δ	0 %	
DESIRABLE		2	Δ	75 %	DESIRABLE
UNNECESSARY	2		Δ	25 %	

DEGREE OF RISK

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE	1		Δ	8 %	
.4 EXPERIMENTAL		8	Δ	8 %	
.7 SIMULATION	10		Δ	17 %	
.9 UNPROVEN		3	Δ	67 %	.9

DESIRED COURSE OF ACTION

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL		8	Δ	17 %	
MEDIUM	13		Δ	33 %	
LONG		8	Δ	17 %	
UNDESIRABLE	3		Δ	33 %	UNDESIRABLE

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	o-----o	3.6	76	76.9	3 - 7 YRS.
11	MOST LIKELY	o-------o	6.4	77/78	80.7	5 - 12 YRS.
11	NOT LATER THAN	o-------o	8.5	80	84.9	8½ - 17½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	8.3	2 M	8.73M	4.19 - 13.27
11	UPPER LIMIT	28.4	3 M	23.36M	7.87 - 38.86

DOT ASSESSMENT RESULTS

EVENT: VIB06 A wide field TV system having a 100° x 100° FOV (employing rotating optics). System shall resolve a 25% reflecting 4-inch object against a black background anywhere within FOV at a signal-to-noise ratio of unity at a 70 ft receiver-to-target plane distance in water with an attenuation coefficient of .33/meter. Depth of field is ± 20 ft across FOV. Image will not be degraded by platform speeds of up to 6 knots. Input power, weight, duty cycle same as VIB04.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL			Δ	0 %	
DESIRABLE	3		Δ	70 %	DESIRABLE
UNNECESSARY		3	Δ	30 %	

DEGREE OF RISK

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL			Δ	0 %	
.7 SIMULATION		4	Δ	44 %	
.9 UNPROVEN	4		Δ	56 %	.9

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL	8		Δ	10 %	
MEDIUM		3	Δ	30 %	
LONG		2	Δ	20 %	
UNDESIRABLE		3	Δ	40 %	UNDESIRABLE

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	o---o	2.4	75/80	76.4	3 - 6 YRS
9	MOST LIKELY	o----o	4.5	78	80.6	6 - 11½ YRS
9	NOT LATER THAN	o-------o	6.7	NONE	84.7	8½ - 17 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	8.5	2 M	7.44M	2.16 - 12.73
9	UPPER LIMIT	16.3	3,10 M	16.67M	6.58 - 26.76

DOT ASSESSMENT RESULTS

EVENT: VIB07 Same as VIB06 except available power is 30 kw and maximum range is 85 ft. Weight and size suitable for towed fish or submersible.

SYSTEM CRITICALITY

N = 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL			Δ	0 %	
DESIRABLE	5.5		Δ	40 %	
UNNECESSARY		5.5	Δ	60 %	UNNECESSARY

DEGREE OF RISK

N = 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL			Δ	0 %	
.7 SIMULATION		8.5	Δ	37.5 %	
.9 UNPROVEN	8.5		Δ	62.5 %	.9

DESIRED COURSE OF ACTION

N = 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL	17		Δ	10 %	
MEDIUM		10	Δ	10 %	
LONG		2	Δ	20 %	
UNDESIRABLE		5	Δ	60 %	UNDESIRABLE

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
8	EARLIEST	o----- o	3.0	80	77.0	3 - 7 YRS.
8	MOST LIKELY	o-------o	5.2	85	81.0	5½ - 12½ YRS.
8	NOT LATER THAN	o-------- o	7.7	90	85.5	8½ - 18½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
8	LOWER LIMIT	7.4	10M	9.13M	4.19 - 14.10
8	UPPER LIMIT	17.1	10M	23.75M	12.30 - 35.20

DOT ASSESSMENT RESULTS

EVENT: VIB08 A 5° FOV TV system using expendable underwater flares which will image a 1 inch 25% reflecting target against a black background anywhere within FOV for a targer distance of up to 160 ft in water with an attenuation coefficient of .25/meter. Resolution will not be degraded by vehicle motions of up to 6 knots. System will be provided with 100 flares which can be fired automatically to ranges of up to 160 ft and each flare will last at least 30 seconds. Weight of system shall not exceed 150 lbs in water.

SYSTEM CRITICALITY

	PERCENTAGE		FINAL CONSENSUS %		
N= 11	LOSS	GAIN	0 25 50 75 100		CONCLUSION
ESSENTIAL			Δ	0%	
DESIRABLE	6		Δ	36%	
UNNECESSARY		6	Δ	64%	UNNECESSARY

DEGREE OF RISK

	PERCENTAGE		FINAL CONSENSUS %		
N= 10	LOSS	GAIN	0 25 50 75 100		CONCLUSION
.1 PROTOTYPE			Δ	0%	
.4 EXPERIMENTAL			Δ	0%	
.7 SIMULATION	7		Δ	60%	.7
.9 UNPROVEN		7	Δ	40%	

DESIRED COURSE OF ACTION

	PERCENTAGE		FINAL CONSENSUS %		
N= 11	LOSS	GAIN	0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL			Δ	0%	
MEDIUM	6		Δ	27%	
LONG		1	Δ	9%	
UNDESIRABLE		5	Δ	64%	UNDESIRABLE

PROBABLE TIMING

		CALENDAR YEARS (90% CONFIDENCE INTERVAL)				
N		72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	o------- o	4.7	75	76.6	2 - 7½ YRS.
10	MOST LIKELY	o------o	5.7	78/80	80.3	5 - 11½ YRS.
10	NOT LATER THAN	o-------o	6.9	90	83.5	7½ - 15½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	4.8	1 M	4.65M	1.86 - 7.44
10	UPPER LIMIT	20.0	3,5 M	16.30M	4.68 - 27.92

DOT ASSESSMENT RESULTS

EVENT: VIB09 A high sensitivity gradiometer/magnetometer system capable of locating and tracking small anomolies (i.e., a moving submersible) to within ± 20 ft. The system is capable of operating from or beneath the surface and can track objects down to ocean depths of 20,000 ft.

SYSTEM CRITICALITY

N = 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL		5	Δ	36 %	
DESIRABLE	5		Δ	64 %	DESIRABLE
UNNECESSARY			Δ	0 %	

DEGREE OF RISK

N = 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL			Δ	0 %	
.7 SIMULATION	3.5		Δ	54.5 %	.7
.9 UNPROVEN		3.5	Δ	45.5 %	

DESIRED COURSE OF ACTION

N = 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL			Δ	20%	
MEDIUM	13		Δ	20%	
LONG		10	Δ	50%	LONG
UNDESIRABLE		3	Δ	10%	·

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	o-----------o	7.6	75	78.2	2 - 10½ YRS.
9	MOST LIKELY	o---o	3.3	75/80	79.0	5 - 9 YRS.
9	NOT LATER THAN	o----o	4.9	83/90	83.1	8 - 14 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	29.2	2,3 M	17.88 M	1.93 - 33.84
11	UPPER LIMIT	140.6	5 M	63.73 M	0 - 140.52

DOT ASSESSMENT RESULTS

EVENT: VIB10 A focused imaging system using a 100 x 100 element or equivalent hydrophone array capable of resolving a 24-inch effective target against a neutral background at a 100-ft range.

SYSTEM CRITICALITY

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL		1	15 %	
DESIRABLE	3		54 %	DESIRABLE
UNNECESSARY		2	31 %	

DEGREE OF RISK

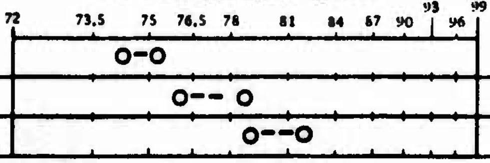
N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL		7	54 %	.4
.7 SIMULATION	7		31 %	
.9 UNPROVEN			15 %	

DESIRED COURSE OF ACTION

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	6		23 %	
MEDIUM		2	39 %	MEDIUM
LONG		2	15 %	
UNDESIRABLE		2	23 %	

PROBABLE TIMING

CALENDAR YEARS
(90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
13	EARLIEST	1.4	74/75	74.8	2 - 3½ YRS.
11	MOST LIKELY	2.0	76	77.2	4 - 6½ YRS.
13	NOT LATER THAN	3.3	78/85	80.3	6½ - 10 YRS.

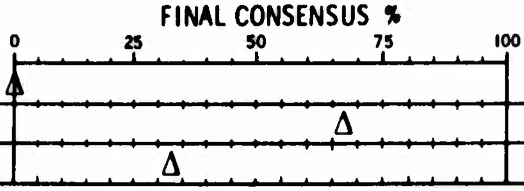
ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
13	LOWER LIMIT	2.6	1 M	2.50 M	1.22 - 3.78
13	UPPER LIMIT	6.5	3 M	6.27 M	3.04 - 9.50

DOT ASSESSMENT RESULTS

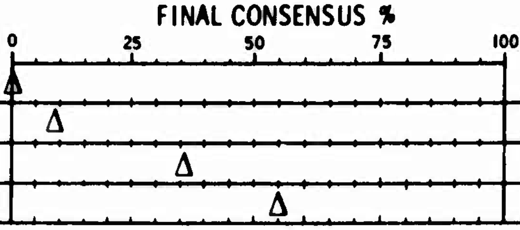
EVENT: VIB11 A focused holographic imaging system ... same as VIB10.

SYSTEM CRITICALITY



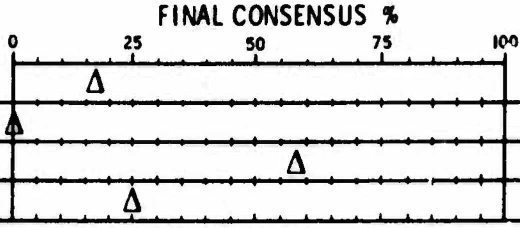
N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN		CONCLUSION
ESSENTIAL			0 %	
DESIRABLE			67 %	DESIRABLE
UNNECESSARY			33 %	

DEGREE OF RISK



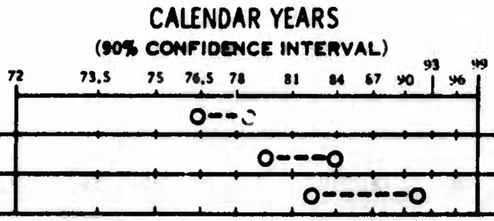
N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN		CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL	1		9 %	
.7 SIMULATION	4		36 %	
.9 UNPROVEN		5	55 %	.9

DESIRED COURSE OF ACTION



N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN		CONCLUSION
SHORT RANGE GOAL			17 %	
MEDIUM	8		0 %	
LONG		8	58 %	LONG
UNDESIRABLE			25 %	

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	1.9	75	77.3	4 - 6½ YRS.
11	MOST LIKELY	4.1	85	81.8	7½ - 12 YRS.
11	NOT LATER THAN	6.8	80	86.4	10½ - 18 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	7.1	2, 3 M	6.9 M	3.00 - 10.73
11	UPPER LIMIT	18.0	10 M	17.7 M	7.81 - 27.55

DOT ASSESSMENT RESULTS

EVENT: VIB12 A focused acoustic imaging system using a 100 x 100 element hydrophone array capable of resolving a 24-inch effective target against a neutral background at a 300-ft range.

SYSTEM CRITICALITY

N= 12	PERCENTAGE LOSS	 GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL			Δ	0 %	
DESIRABLE	2		Δ	83 %	DESIRABLE
UNNECESSARY		2	Δ	17 %	

DEGREE OF RISK

N= 12	PERCENTAGE LOSS	 GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE	8		Δ	0 %	
.4 EXPERIMENTAL			Δ	8 %	
.7 SIMULATION			Δ	67 %	.7
.9 UNPROVEN		8	Δ	25 %	

DESIRED COURSE OF ACTION

N= 12	PERCENTAGE LOSS	 GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL	8		Δ	0 %	
MEDIUM	14		Δ	17 %	
LONG		20	Δ	66 %	LONG
UNDESIRABLE		2	Δ	17 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	o----- o	4.1	76	77.8	3½ - 8 YRS.
12	MOST LIKELY	o----- o	5.1	77	80.4	6 - 11 YRS
12	NOT LATER THAN	o----- o	6.1	85	83.6	8½ - 14½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
12	LOWER LIMIT	13.2	2 M	8.21M	1.35 - 15.07
12	UPPER LIMIT	27.5	5 M	18.33M	4.07 - 32.60

DOT ASSESSMENT RESULTS

EVENT: VIB13 A focused acoustic holographic ranging system ... same as VIB12.

SYSTEM CRITICALITY

N- 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL			0 %	
DESIRABLE			82 %	DESIRABLE
UNNECESSARY			18 %	

DEGREE OF RISK

N- 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL	1		10 %	
.7 SIMULATION		7	40 %	
.9 UNPROVEN	6		50 %	.9

DESIRED COURSE OF ACTION

N- 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			0 %	
MEDIUM			9 %	
LONG			73 %	LONG
UNDESIRABLE			18 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL)	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST		5.7	80	80.2	5 - 11½ YRS
10	MOST LIKELY		6.5	78/85	84.2	8½ - 16 YRS.
10	NOT LATER THAN		7.4	90	87.9	11½ - 20 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	21.3	3,8 M	4.55M	2.21 - 26.89
10	UPPER LIMIT	42.5	15,50M	32.00M	7.36 - 56.64

DOT ASSESSMENT RESULTS

EVENT: VIB14 A sensor system capable of covert, real-time monitoring of the physical positions of an array of individually suspended passive ASW surveillance hydrophone during surveillance operations throughout a five-year operating life of the array. The system would be capable of determining the relative positions of the acoustic elements within ± 0.8 ft displacement in any direction per 100 ft of length along the array.

SYSTEM CRITICALITY

N= 11	PERCENTAGE LOSS	 GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL	5		Δ	18 %	
DESIRABLE			Δ	46 %	DESIRABLE
UNNECESSARY		5	Δ	36 %	

DEGREE OF RISK

N= 10	PERCENTAGE LOSS	 GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL	5		Δ	20 %	
.7 SIMULATION		12	Δ	70 %	.7
.9 UNPROVEN	7		Δ	10 %	

DESIRED COURSE OF ACTION

N= 11	PERCENTAGE LOSS	 GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL	6		Δ	9 %	
MEDIUM		4	Δ	27 %	
LONG	2		Δ	37 %	LONG
UNDESIRABLE		4	Δ	27 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	o---o	2.3	74/78	76.7	3½ - 6 YRS.
10	MOST LIKELY	o----o	4.4	78	80.5	6 - 11 YRS.
10	NOT LATER THAN	o-----o	6.6	80	84.5	8½ - 16½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ^2	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	4.2	5 M	5.00M	2.59 - 7.41
10	UPPER LIMIT	13.0	10 M	14.45M	6.89 - 22.01

DOT ASSESSMENT RESULTS

EVENT: VIB15 A sensor system capable of covert, real-time monitoring of the physical positions of an array of individually suspended passive ASW surveillance hydrophone during the installation of an array to water depths of 20,000 ft. The system would ... same as VIB14.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	3		30 %	
DESIRABLE		11	70 %	DESIRABLE
UNNECESSARY	8		0 %	

DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE	9		0 %	
.4 EXPERIMENTAL		3	30 %	
.7 SIMULATION		15	70 %	.7
.9 UNPROVEN	9		0 %	

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		2	20 %	
MEDIUM	16		30 %	
LONG		23	50 %	LONG
UNDESIRABLE	9		0 %	

PROBABLE TIMING

CALENDAR YEARS
(90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	2.5	74	75.7	2 - 5 YRS.
10	MOST LIKELY	3.6	77/80	78.7	4½ - 9 YRS.
10	NOT LATER THAN	5.0	80	81.9	7 - 13 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	6.0	2,5 M	6.75M	3.30 - 10.20
10	UPPER LIMIT	16.0	5,10 M	16.15 M	6.86 - 25.40

VIC Sub-Technology: Communications

Objective: To advance the technologies necessary for real-time, reliable, quality voice and data communications links between the various surface and bottom facilities and vehicles in the environment required.

Events VIC01 - VIC09 address this objective.

DOT ASSESSMENT RESULTS

EVENT: VIC01 An underwater acoustic, multi-channel (voice and digital data), high data rate communication link capable of secure communications between submersibles, bottom habitats, and the surface at 20-mile distances and down to 20,000 ft ocean depths with negligible multi-path and reverberation interference.

SYSTEM CRITICALITY

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL		5	62 %	ESSENTIAL
DESIRABLE	5		38 %	
UNNECESSARY			0 %	

DEGREE OF RISK

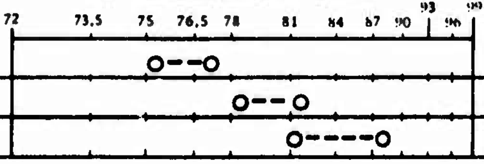
N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE		1	8 %	
.4 EXPERIMENTAL		1	15 %	
.7 SIMULATION		9.5	38.5 %	.7
.9 UNPROVEN	11.5		38.5 %	

DESIRED COURSE OF ACTION

N= 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	13		14 %	
MEDIUM		16	36 %	
LONG		10	50 %	LONG
UNDESIRABLE	13		0 %	

PROBABLE TIMING

CALENDAR YEARS
(90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
13	EARLIEST	2.0	75	76.3	3½ - 5½ YRS.
13	MOST LIKELY	4.3	80	80.5	6½ - 10½ YRS.
13	NOT LATER THAN	6.6	90	84.8	9½ - 16 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
13	LOWER LIMIT	12.8	3 M	10.23M	3.92 - 16.55
13	UPPER LIMIT	33.0	5 M	28.35M	12.53 - 45.17

DOT ASSESSMENT RESULTS

EVENT: VIC02 An underwater laser multi-channel, high data rate, communication link between submersibles, habitats, and the surface with a range of 1,000 ft in seawater with a light attenuation coefficient of 0.12/meter.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL		1	Δ	10 %	
DESIRABLE	5.5		Δ	40 %	
UNNECESSARY		4.5	Δ	50 %	UNNECESSARY

DEGREE OF RISK

N= 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL			Δ	0 %	
.7 SIMULATION			Δ	33 %	
.9 UNPROVEN			Δ	67 %	.9

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL	10		Δ	0 %	
MEDIUM		10	Δ	20 %	
LONG	10		Δ	20 %	
UNDESIRABLE		10	Δ	60 %	UNDESIRABLE

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	o--- o	3.1	76	77.4	3½ - 7½ YRS.
9	MOST LIKELY	o-----o	5.4	78	81.6	6½ - 13 YRS.
9	NOT LATER THAN	o-------o	7.9	80/85	85.9	9 - 19 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	14.7	5 M	8.61M	0 - 17.73
9	UPPER LIMIT	28.4	10 M	20.22M	2.58- 37.86

DOT ASSESSMENT RESULTS

EVENT: VIC03 An underwater portable acoustic, two-way voice communications link for communications between divers, habitats, vehicles and the surface, capable of functioning reliably down to 1,000 ft depths and over a range of 1 mile.

SYSTEM CRITICALITY

N= 13	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
ESSENTIAL		5	Δ	69 %	ESSENTIAL
DESIRABLE	5		Δ	31 %	
UNNECESSARY			Δ	0 %	

DEGREE OF RISK

N= 13	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
.1 PROTOTYPE		9	Δ	23 %	
.4 EXPERIMENTAL	11		Δ	54 %	.4
.7 SIMULATION		1	Δ	15 %	
.9 UNPROVEN		1	Δ	8 %	

DESIRED COURSE OF ACTION

N= 12	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
SHORT RANGE GOAL		21	Δ	83 %	SHORT
MEDIUM	21		Δ	17 %	
LONG			Δ	0 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
13	EARLIEST	o-o	.9	73	73.7	1 - 2 YRS.
13	MOST LIKELY	o- o	1.9	74/75	75.4	2½ - 4½ YRS.
13	NOT LATER THAN	o--- o	2.9	77	77.4	4 - 7 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
13	LOWER LIMIT	1.2	.5 M	.97 M	.38 - 1.56
13	UPPER LIMIT	2.5	5 M	3.30 M	2.03 - 4.56

DOT ASSESSMENT RESULTS

EVENT: VIC04 A helium-speech unscrambler for two-way voice communications between divers, habitats, vehicles, and the surface, capable of functioning reliably down to 1,000-ft depths.

SYSTEM CRITICALITY

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	3		61 %	ESSENTIAL
DESIRABLE		2	31 %	
UNNECESSARY		1	8 %	

DEGREE OF RISK

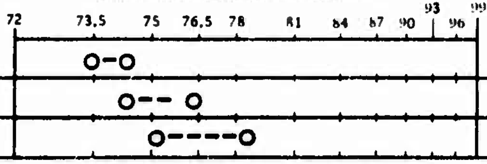
N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE		18	54 %	.1
.4 EXPERIMENTAL	5		23 %	
.7 SIMULATION	13		23 %	
.9 UNPROVEN			0 %	

DESIRED COURSE OF ACTION

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		6	75 %	SHORT
MEDIUM	6		17 %	
LONG			0 %	
UNDESIRABLE			8 %	

PROBABLE TIMING

CALENDAR YEARS
(90% CONFIDENCE INTERVAL)



N		σ^2	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
13	EARLIEST	1.0	73/74	73.9	1½ - 2½ YRS
13	MOST LIKELY	1.9	74	75.5	2½ - 4½ YRS.
13	NOT LATER THAN	3.1	75	77.2	3½ - 7 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
13	LOWER LIMIT	.5	.5 M	.62 M	.37 - .87
13	UPPER LIMIT	1.7	1 M	1.84 M	.98 - 2.70

DOT ASSESSMENT RESULTS

EVENT: VIC05 A tactile (physical stimulus of different body areas) two-way communications system for use as a means of communications.

SYSTEM CRITICALITY

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL			Δ	0 %	
DESIRABLE	5		Δ	33 %	
UNNECESSARY		5	Δ	67 %	UNNECESSARY

DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL	10		Δ	0 %	
.7 SIMULATION			Δ	20 %	
.9 UNPROVEN		10	Δ	80 %	.9

DESIRED COURSE OF ACTION

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL			Δ	0 %	
MEDIUM		7	Δ	17 %	
LONG		3	Δ	33 %	
UNDESIRABLE	10		Δ	50 %	UNDESIRABLE

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	o---o	2.4	78/80	76.6	3 - 6 YRS.
10	MOST LIKELY	o--o	3.3	80/85	80.4	6½ - 10½ YRS.
10	NOT LATER THAN	o----o	5.9	90	84.6	9 - 16 YRS.

ESTIMATED COSTS TO ACHIEVE

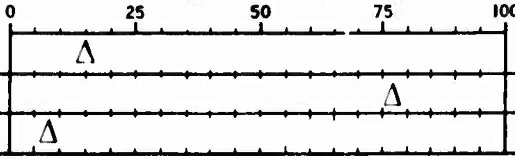
N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	3.0	.5, 5 M	3.16M	1.28 - 5.03
9	UPPER LIMIT	5.4	1,10 M	4.61M	1.84 - 7.38

DOT ASSESSMENT RESULTS

EVENT: VIC06 A wireless split transformer link through a pressure hull of appropriate material, without penetration, capable of transmitting two-way multi-channel digital communication signals at ocean depths down to 20,000 ft.

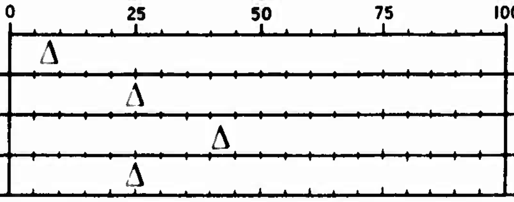
SYSTEM CRITICALITY

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL		2	15 %	
DESIRABLE		3	77 %	DESIRABLE
UNNECESSARY	5		8 %	



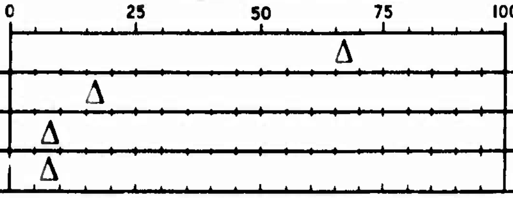
DEGREE OF RISK

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE		1	8 %	
.4 EXPERIMENTAL	11		25 %	
.7 SIMULATION		6	42 %	.7
.9 UNPROVEN		4	25 %	

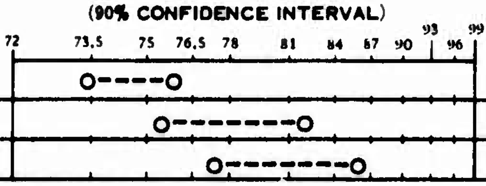


DESIRED COURSE OF ACTION

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		13	67 %	SHORT
MEDIUM		9	17 %	
LONG	15		8 %	
UNDESIRABLE	7		8 %	



PROBABLE TIMING



N		σ^2	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	2.6	73/75	74.7	1½ - 4 YRS.
11	MOST LIKELY	5.3	74	78.6	3½ - 9½ YRS
12	NOT LATER THAN	8.4	76	81.9	5½ - 14½ YRS.

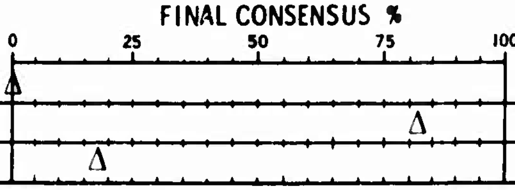
ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
12	LOWER LIMIT	2.9	1 M	3.55 M	1.50 - 5.61
12	UPPER LIMIT	5.3	3,15 M	4.36M	1.57 - 7.16

DOT ASSESSMENT RESULTS

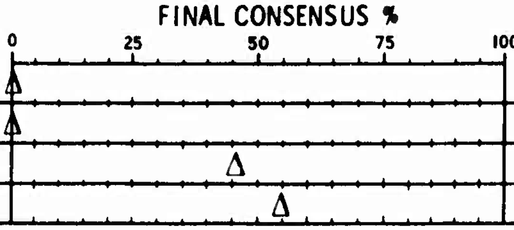
EVENT: VIC07 A wireless, microwave/electrical link ... same as VIC06.

SYSTEM CRITICALITY



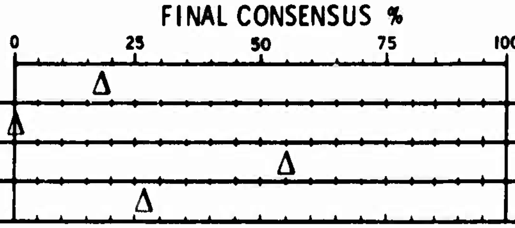
N= 11	PERCENTAGE		FINAL CONSENSUS %	CONCLUSION
	LOSS	GAIN		
ESSENTIAL			0 %	
DESIRABLE		27.5	82 %	DESIRABLE
UNNECESSARY	27.5		18 %	

DEGREE OF RISK



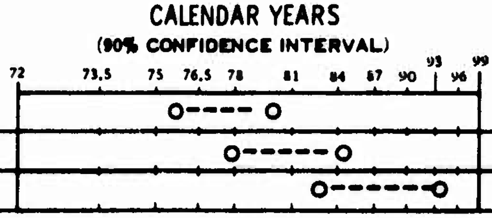
N= 11	PERCENTAGE		FINAL CONSENSUS %	CONCLUSION
	LOSS	GAIN		
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL			0 %	
.7 SIMULATION		25.5	45.5 %	
.9 UNPROVEN	25.5		54.5 %	.9

DESIRED COURSE OF ACTION



N= 11	PERCENTAGE		FINAL CONSENSUS %	CONCLUSION
	LOSS	GAIN		
SHORT RANGE GOAL		8	18 %	
MEDIUM	10		0 %	
LONG		15	55 %	LONG
UNDESIRABLE	13		27 %	

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	3.9	76	78.0	3½ - 8½ YRS.
11	MOST LIKELY	6.5	76/78	81.6	6 - 13 YRS.
10	NOT LATER THAN	9.6	2000	88.5	11 - 22 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	3.7	1 M	3.64M	1.62 - 5.66
11	UPPER LIMIT	8.4	5,10 M	10.23M	5.62 - 14.83

DOT ASSESSMENT RESULTS

EVENT: VIC08 A wireless, optical/electrical link ... same as VIC06.

SYSTEM CRITICALITY

N- 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL			Δ	8 %	
DESIRABLE		8	Δ	75 %	DESIRABLE
UNNECESSARY	8		Δ	17 %	

DEGREE OF RISK

N- 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE		8	Δ	8 %	
.4 EXPERIMENTAL			Δ	0 %	
.7 SIMULATION			Δ	42 %	
.9 UNPROVEN	8		Δ	50 %	.9

DESIRED COURSE OF ACTION

N- 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL	1		Δ	8 %	
MEDIUM	2		Δ	25 %	
LONG		4	Δ	50 %	LONG
UNDESIRABLE	1		Δ	17 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	o---o	2.5	76	76.6	3½ - 6 YRS.
12	MOST LIKELY	o-----o	4.4	78	79.8	5½ - 10 YRS.
11	NOT LATER THAN	o------o	8.0	80/90	86.1	9½ - 18½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
12	LOWER LIMIT	3.3	1,5 M	3.60M	1.89 - 5.31
12	UPPER LIMIT	11.4	3,10M	11.42M	5.52 - 17.31

DOT ASSESSMENT RESULTS

EVENT: VIC09 A wireless, acoustical, remotely-controlled electrical link ... same as VIC06.

SYSTEM CRITICALITY

N· 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL	14		Δ	15 %	
DESIRABLE		14	Δ	85 %	DESIRABLE
UNNECESSARY			Δ	0 %	

DEGREE OF RISK

N· 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL		2	Δ	31 %	
.7 SIMULATION	3		Δ	61 %	.7
.9 UNPROVEN		1	Δ	8 %	

DESIRED COURSE OF ACTION

N· 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL	6		Δ	15%	
MEDIUM		5	Δ	70%	MEDIUM
LONG		1	Δ	15%	
UNDESIRABLE			Δ	0%	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	o----o	2.3	75	75.5	2½ - 4½ YRS.
13	MOST LIKELY	o-----o	4.4	78	78.3	4 → 8½ YRS.
12	NOT LATER THAN	o------o	6.6	80	82.0	6½ - 13½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
13	LOWER LIMIT	2.8	.5 M	2.02 M	.64 - 3.40
13	UPPER LIMIT	7.7	2 M	5.52 M	1.72 - 9.31

APPENDIX G

TECHNOLOGY AREA VII. INSTRUMENTATION AND DISPLAY

SUB-TECHNOLOGY AREAS:

A. Life Support Monitoring
B. Submersible Positioning and Guidance Instrumentation
C. Site Selection Instruments

VIIA Sub-Technology: Life Support Monitoring

Objective: To develop the technologies to continuously monitor major parameters of a life-support system including automatic warning devices.

Events VIIA01 - VIIA03 address this objective.

DOT ASSESSMENT RESULTS

EVENT: VIIA01

A carbon dioxide indicator for use in normal atmosphere manned submersibles. The unit indicates the partial pressure of CO_2 from 0 to 30.0 mm hg, and has a settable high level warning signal. The minimum reading is 1.0 mm hg, and the accuracy is within ± 10 mm hg (0 to 4% CO_2 in increments of .13%). The instrument is approximately 8x10x12 inches, weighs less than 4 pounds, and requires less than 10 w. at 28 VDC. The instrument will remain within calibration for 1,000 hrs without maintenance, and the MTBF is 5,000 hrs of operation.

SYSTEM CRITICALITY

N= 6	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	4.5		33 %	
DESIRABLE		4.5	67 %	DESIRABLE
UNNECESSARY			0 %	

DEGREE OF RISK

N= 6	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE	8		17 %	
.4 EXPERIMENTAL		8	83 %	.4
.7 SIMULATION			0 %	
.9 UNPROVEN			0 %	

DESIRED COURSE OF ACTION

N= 5	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	2.5		60 %	SHORT
MEDIUM	5		20 %	
LONG		7.5	20 %	
UNDESIRABLE			0 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
6	EARLIEST	.3	73	73.2	1 - 1 1/2 YRS
6	MOST LIKELY	.9	74	74.3	1 1/2 - 3 YRS
6	NOT LATER THAN	.9	75	75.7	3 - 4 1/2 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
6	LOWER LIMIT	.2	.05 M	.17 M	.03 - .31
6	UPPER LIMIT	1.0	None M	.91 M	.05 - 1.77

DOT ASSESSMENT RESULTS

EVENT: VIIA02 An instrument as described VIIA01, but which does not require any electrical power, except for the warning signal which is fail-safe.

SYSTEM CRITICALITY

N: 5	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL				0 %	
DESIRABLE		25		100 %	DESIRABLE
UNNECESSARY	25			0 %	

DEGREE OF RISK

N: 5	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE		6		20 %	
.4 EXPERIMENTAL	9			20 %	
.7 SIMULATION	14			0 %	
.9 UNPROVEN		17		60 %	.9

DESIRED COURSE OF ACTION

N: 2	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL	25			0 %	
MEDIUM		50		100 %	MEDIUM
LONG	25			0 %	
UNDESIRABLE				0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
5	EARLIEST		1.0	74	74.4	1 1/2 - 3 1/2 YRS.
5	MOST LIKELY		1.7	75,78	76.0	2 1/2 - 5 1/2 YRS.
5	NOT LATER THAN		1.9	76	77.2	3 1/2 - 7 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
5	LOWER LIMIT	.6	NoneM	.55 M	0 - 1.12
5	UPPER LIMIT	2.2	5 M	2.36 M	.29 - 4.43

DOT ASSESSMENT RESULTS

VIIA03 A multipurpose atmospheric contaminant indicator for use in normal atmosphere manned submersibles, which senses and indicates the concentrations of carbon monoxide, hydrogen, Freons, and general hydrocarbons. (The instrument has an indication, specific to methane.) The ranges and sensitivities are listed below:

Contaminant	Range	Min. Sensitivity
Carbon Monoxide	0 - 200 ppm	5 ppm
Hydrogen	0 - 3%	.25%
Freons	0 - 500 ppm	25 ppm
Methane	0 - 10%	.5%
Hydrocarbons	0 - 200 ppm	5 ppm

The instrument is approximately 8 x 10 x 12 inches, weighs less than 10 pounds and requires 20 w at 28 VDC. The instrument will remain in calibration for 1,000 hours without maintenance and the MTBF is 5,000 hours.

SYSTEM CRITICALITY

N= 5	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL			0 %	
DESIRABLE	7		60 %	DESIRABLE
UNNECESSARY		7	40 %	

DEGREE OF RISK

N= 5	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL			0 %	
.7 SIMULATION		7	40 %	
.9 UNPROVEN	7		60 %	.9

DESIRED COURSE OF ACTION

N= 3	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			0 %	
MEDIUM			0 %	
LONG			100 %	LONG
UNDESIRABLE			0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
4	EARLIEST		.7	75	75.0	2 - 4 YRS.
4	MOST LIKELY		1.1	None	77.5	4 - 7 YRS
4	NOT LATER THAN		1.6	None	80.0	6 - 10 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
4	LOWER LIMIT	.2	1 M	.80 M	.55 - 1.05
4	UPPER LIMIT	2.8	NoneM	3.13M	0 - 6.46

VIIB Sub-Technology: Submersible Positioning and Guidance Instrumentation

Objective: To advance the technologies necessary to accurately traverse preplanned tracks across the bottom and at various altitudes in the water column.

Events VIIB01 - VIIB06 address this objective.

DOT ASSESSMENT RESULTS

EVENT: VIIB01 A gyroscopic compass of the marine type which is completely self-contained in a 12 x 12 x 8 inch volume, weighs less than 30 pounds, and requires less than 40 w at 28 VDC. The instrument can be brought up to speed and aligned to true north in 30 minutes, after which it will hold its heading within ± 1° for 30 days, and MTBF is at least 10,000 hours.

SYSTEM CRITICALITY

N- 7	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL		16	86 %	ESSENTIAL
DESIRABLE	16		14 %	
UNNECESSARY			0 %	

DEGREE OF RISK

N- 7	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL		1	71 %	.4
.7 SIMULATION	1		29 %	
.9 UNPROVEN			0 %	

DESIRED COURSE OF ACTION

N- 7	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		11	71 %	SHORT
MEDIUM	1		29 %	
LONG	10		0 %	
UNDESIRABLE			0 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

72 73.5 75 76.5 78 81 84 87 90 93 96 99

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
7	EARLIEST	.8	73	73.9	1 - 2 1/2 YRS
7	MOST LIKELY	2.1	74,75	76.1	2 1/2 - 5 1/2 YRS
7	NOT LATER THAN	3.4	75	78.7	4 - 9 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
7	LOWER LIMIT	.7	.2 M	.64 M	.11 - 1.16
7	UPPER LIMIT	2.6	.5 M	2.86 M	.94 - 4.78

DOT ASSESSMENT RESULTS

EVENT: VIIB02

An absolute velocity and path over the bottom indicator based on the doppler sonar method. In addition to digital readouts, the instrument provides an actual trace of the submersibles' path on a map of the bottom. The instrument operates accurately at heights up to 400 ft. over the bottom and is self-compensating for vehicle pitch and roll. The complete system weighs less than 100 pounds, occupies 3 cubic feet, and requires 200 w at 28 VDC. MTBF for the system is at least 400 hours.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	7		10 %	
DESIRABLE		7	90 %	DESIRABLE
UNNECESSARY			0 %	

DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE		2	20 %	
.4 EXPERIMENTAL		2	20 %	
.7 SIMULATION	4		60 %	.7
.9 UNPROVEN			0 %	

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		2	10 %	
MEDIUM	4		80 %	MEDIUM
LONG		2	10 %	
UNDESIRABLE			0 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	.6	74	74.2	2 - 2 1/2 YRS.
10	MOST LIKELY	1.1	76	76.0	3 1/2 - 4 1/2 YRS
10	NOT LATER THAN	1.8	78	78.2	5 - 7 1/2 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	.5	.3 M	.62 M	.32 - .92
10	UPPER LIMIT	2.6	1 M	2.38 M	.86 - 3.90

DOT ASSESSMENT RESULTS

EVENT: VIIB03 A relative velocity indicator that displays and records the relative speed and direction of a submersible through the water, based on direct sensing of water movement. The instrument will show direction in 3 dimensions to ± 1.0°, and speed from 0 to 10 knots with an accuracy of ± 0.1 knot at the low end of the scale and an overall maximum error of 0.25 knots. The sensor is of rugged construction and resiliently mounted. Total system weight is less than 20 pounds; the display and recorder units are less than 8 x 12 x 15 inches, weigh under 15 pounds, and power consumption is less than 50 w. The system retains its calibration for 1,000 hours and MTBF is at least 5,000 hours.

SYSTEM CRITICALITY

N° 10	PERCENTAGE LOSS	 GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL	9			0 %	
DESIRABLE		18		100 %	ESSENTIAL
UNNECESSARY	9			0 %	

DEGREE OF RISK

N° 9	PERCENTAGE LOSS	 GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE		1		11 %	
.4 EXPERIMENTAL		7		67 %	.4
.7 SIMULATION	8			22 %	
.9 UNPROVEN				0 %	

DESIRED COURSE OF ACTION

N° 9	PERCENTAGE LOSS	 GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL				22 %	
MEDIUM				78 %	MEDIUM
LONG				0 %	
UNDESIRABLE				0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST		.5	74	73.9	1 1/2 - 2 YRS
9	MOST LIKELY		.9	76	75.9	3 1/2 - 4 1/2 YRS
9	NOT LATER THAN		1.3	78	78.3	5 1/2 - 7 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	.3	.3 M	.38 M	.22 - .54
9	UPPER LIMIT	1.3	1 M	1.29 M	.46 - 2.13

DOT ASSESSMENT RESULTS

EVENT: VIIB04 An instrument ad described in VIIB03 but based on electromagnetic induction.

SYSTEM CRITICALITY

N = 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL				0 %	
DESIRABLE		9		100 %	DESIRABLE
UNNECESSARY	9			0 %	

DEGREE OF RISK

N = 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE	8			22 %	
.4 EXPERIMENTAL		12		22 %	
.7 SIMULATION	6			34 %	.7
.9 UNPROVEN		2		22 %	

DESIRED COURSE OF ACTION

N = 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL	4.5			33 %	
MEDIUM		6		56 %	MEDIUM
LONG	1.5			11 %	
UNDESIRABLE				0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL)	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	o-o	.9	75	74.1	11/2 - 2 1/2 YRS
9	MOST LIKELY	o--o	1.4	77	75.9	3 - 5 YRS
9	NOT LATER THAN	o--o	3.0	80	78.4	4 1/2 - 8 1/2 YRS

ESTIMATED COSTS TO ACHIEVE

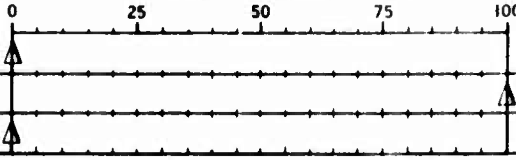
N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	.3	.1 M	.35 M	.18 - .52
9	UPPER LIMIT	1.3	1 M	1.31 M	.47 - 2.15

DOT ASSESSMENT RESULTS

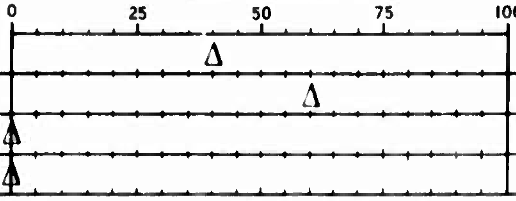
EVENT: VIIB05

A depth variation indicator which determines depth by pressure and shows variations as small as ± 2 ft in depth after being set at the desired depth. The instrument is accurate down to 20,000 ft. and will maintain a fixed setting with a 20 - ft. (10 psi) range for 24 hours. It weighs 25 pounds, occupies 8 x 10 x 12 inches, requires 40 w. at 28 VDC, and MTBF is 4,000 hours.

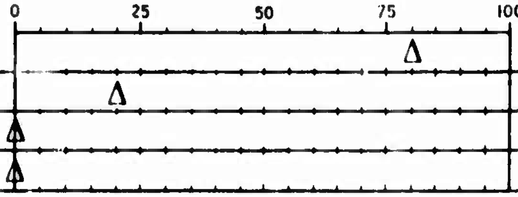
SYSTEM CRITICALITY

N = 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL				0 %	
DESIRABLE				100 %	DESIRABLE
UNNECESSARY				0 %	

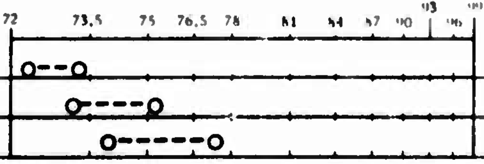
DEGREE OF RISK

N = 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE		13		40 %	
.4 EXPERIMENTAL		5		60 %	.4
.7 SIMULATION	18			0 %	
.9 UNPROVEN				0 %	

DESIRED COURSE OF ACTION

N = 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL		20		80 %	SHORT
MEDIUM	10			20 %	
LONG	10			0 %	
UNDESIRABLE				0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST		1.1	73	72.8	0 - 1 1/2 YRS
10	MOST LIKELY		1.9	74	74.2	1 - 3 1/2 YRS
10	NOT LATER THAN		3.0	75	75.8	2 - 5 1/2 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	.1	.1 M	.10 M	.06 - .14
10	UPPER LIMIT	.2	.5 M	.41 M	.29 - .53

DOT ASSESSMENT RESULTS

EVENT: VIIB06

A rate of descent or ascent indicator which senses the change in pressure and provides a readout in feet per minute. The instrument has two scales: (1) a sensitive scale reading 0 to 30 feet per minute with a sensitivity of 0.5 fpm and (2) a coarse scale reading 0 to 200 fpm with a sensitivity of 5 fpm. The unit occupies a space of 8 x 10 x 14 inches, weighs 25 pounds, and requires 40 w. at 28 VDC. MTBF is not less than 400 hours.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL	7		Δ	10 %	
DESIRABLE		15	Δ	90 %	DESIRABLE
UNNECESSARY	8		Δ	0 %	

DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE	8		Δ	0 %	
.4 EXPERIMENTAL		23	Δ	90 %	.4
.7 SIMULATION	7		Δ	10 %	
.9 UNPROVEN	8		Δ	0 %	

DESIRED COURSE OF ACTION

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL	16		Δ	20 %	
MEDIUM		14	Δ	60 %	MEDIUM
LONG		11	Δ	20 %	
UNDESIRABLE	9		Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	o--o	.8	73	73.3	1 - 2 YRS
10	MOST LIKELY	o-o	1.2	75	75.0	2 1/2 - 3 1/2 YRS
10	NOT LATER THAN	o----o	2.3	76,77	76.9	3 1/2 - 6 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	.1	.2 M	.16 M	.11 - .21
10	UPPER LIMIT	.3	.5 M	.53 M	.36 - .70

VIIC Sub-Technology: Site Selection Instruments

Objective: To develop and advance the technologies and methods involved to produce instrument systems that can survey in detail potential construction sites.

Events VIIC01 - VIIC12 address this objective.

DOT ASSESSMENT RESULTS

EVENT: VIIC01 A sediment density and water content probe system that can measure the seidment density and water content of seafloor sediments to 10-ft sediment depths, and is capable of operating in 20,000 - ft ocean depths.

SYSTEM CRITICALITY

N 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL	9		Δ	0 %	
DESIRABLE		9	Δ	100 %	DESIRABLE
UNNECESSARY			Δ	0 %	

DEGREE OF RISK

N 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL	1		Δ	89 %	.4
.7 SIMULATION		1	Δ	11 %	
.9 UNPROVEN			Δ	0 %	

DESIRED COURSE OF ACTION

N 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL	10		Δ	0 %	
MEDIUM		10	Δ	100 %	MEDIUM
LONG			Δ	0 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	o o	.4	73	73.3	1 - 1 1/2 YRS
9	MOST LIKELY	o-o	.8	75	75.3	3 - 4 YRS
9	NOT LATER THAN	o-o	1.1	78	77.7	5 - 6 1/2 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	.1	.1 M	.18 M	.10 - .27
9	UPPER LIMIT	.5	.8 M	.63 M	.29 - .99

DOT ASSESSMENT RESULTS

EVENT: VIIC02 A core sampler that can take an undisturbed core sample (suitable for laboratory strength measurement) of seafloor sediment 100 ft. down into the sediment and is capable of operation in ocean depths of 20,000 ft.

SYSTEM CRITICALITY

N = 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL			0 %	
DESIRABLE			100 %	DESIRABLE
UNNECESSARY			0 %	

DEGREE OF RISK

N = 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL		6	70 %	.4
.7 SIMULATION	6		30 %	
.9 UNPROVEN			0 %	

DESIRED COURSE OF ACTION

N = 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		2	20 %	
MEDIUM	4		60 %	MEDIUM
LONG		2	2C %	
UNDESIRABLE			0 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	.5	74	73.9	1 1/2 - 2 YRS
10	MOST LIKELY	1.3	76	76.3	3 1/2 - 5 YRS
10	NOT LATER THAN	1.8	78	78.3	5 1/2 - 8 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	.2	.1,.3 M	.28 M	.17 - .39
10	UPPER LIMIT	.3	1 M	.85 M	.65 - 1.05

DOT ASSESSMENT RESULTS

EVENT: VIIC03 An acoustic/seismic seafloor sub-bottom strata profiler that penetrates the sub-bottom to 1,000 ft while giving a resolution of 1 meter, towable to 20,000 - ft ocean depths.

SYSTEM CRITICALITY

N: 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	9		0 %	
DESIRABLE		9	100 %	DESIRABLE
UNNECESSARY			0 %	

DEGREE OF RISK

N: 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL		1	11 %	
.7 SIMULATION		19	89 %	.7
.9 UNPROVEN	20		0 %	

DESIRED COURSE OF ACTION

N: 9	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		1	11 %	
MEDIUM		28	78 %	MEDIUM
LONG	29		11 %	
UNDESIRABLE			0 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	.5	74	74.1	2 - 2 1/2 YRS
9	MOST LIKELY	.8	76	76.3	4 - 5 YRS
9	NOT LATER THAN	1.5	78	78.8	6 - 7 1/2 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	.2	.5 M	.42 M	.28 - .57
9	UPPER LIMIT	1.3	1 M	1.53M	.73 - 2.33

DOT ASSESSMENT RESULTS

EVENT: VIIC04 A proton magnetometer with a range of 20,000 to 100,000 gamma and a resolution of ± 0.01 gamma, towable and can make measurements in ocean depths down to 20,000 ft.

SYSTEM CRITICALITY

N· 6	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL				0 %	
DESIRABLE		11		100 %	DESIRABLE
UNNECESSARY	11			0 %	

DEGREE OF RISK

N· 6	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE				0 %	
.4 EXPERIMENTAL	8			17 %	
.7 SIMULATION		8		83 %	.7
.9 UNPROVEN				0 %	

DESIRED COURSE OF ACTION

N· 6	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL				0 %	
MEDIUM		7		50 %	MEDIUM
LONG	7			50 %	
UNDESIRABLE				0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
5	EARLIEST		.5	75	74.6	2 - 3 YRS
5	MOST LIKELY		1.0	78	77.2	4 1/2 - 6 YRS
5	NOT LATER THAN		6.0	None	83.2	5 1/2 - 17 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
6	LOWER LIMIT	.1	.3 M	.29 M	.19 - .39
6	UPPER LIMIT	.6	NoneM	.98 M	.49 - 1.48

DOT ASSESSMENT RESULTS

EVENT: VIIC05 A cesium magnetometer/gradiometer...same as VIIC04

SYSTEM CRITICALITY

N· 4	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL			0 %	
DESIRABLE		8	75 %	DESIRABLE
UNNECESSARY	8		25 %	

DEGREE OF RISK

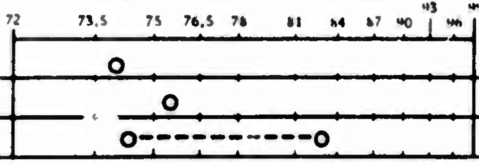
N· 4	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL		5	25 %	
.7 SIMULATION	10		50 %	.7
.9 UNPROVEN		5	25 %	

DESIRED COURSE OF ACTION

N· 4	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			0 %	
MEDIUM		10	50 %	MEDIUM
LONG	15		25 %	
UNDESIRABLE		5	25 %	

PROBABLE TIMING

CALENDAR YEARS
(90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
2	EARLIEST	0	74	74.0	2 - 2 YRS.
2	MOST LIKELY	0	76	76.0	4 - 4 YRS
2	NOT LATER THAN	1.0	None	79.0	2 1/2 - 11 1/2 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
3	LOWER LIMIT	.1	NoneM	.22 M	.04 - .39
3	UPPER LIMIT	.5	NoneM	.80 M	0 - 1.70

DOT ASSESSMENT RESULTS

EVENT: VIIC06 A transmitting and/or recording seismometer, bottom implanted and recoverable at a 20,000-ft. ocean depth that continuously measures the accelerations, resonant frequencies magnitudes, and direction of a seismic disturbance occurring in the deep ocean.

SYSTEM CRITICALITY

N° 6	PERCENTAGE		FINAL CONSENSUS %	CONCLUSION
	LOSS	GAIN		
ESSENTIAL			0 %	
DESIRABLE	4.5		83 %	DESIRABLE
UNNECESSARY		4.5	17 %	

DEGREE OF RISK

N° 5	PERCENTAGE		FINAL CONSENSUS %	CONCLUSION
	LOSS	GAIN		
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL	23		60 %	.4
.7 SIMULATION		23	40 %	
.9 UNPROVEN			0 %	

DESIRED COURSE OF ACTION

N° 5	PERCENTAGE		FINAL CONSENSUS %	CONCLUSION
	LOSS	GAIN		
SHORT RANGE GOAL	20		0 %	
MEDIUM		20	100 %	MEDIUM
LONG			0 %	
UNDESIRABLE			0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL)	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
5	EARLIEST	o-o	.4	74	74.2	2 - 2 1/2 YRS
5	MOST LIKELY	o--o	.8	76	76.6	4 - 5 1/2 YRS
5	NOT LATER THAN	o--o	1.8	78,80	79.8	6 - 9 1/2 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
5	LOWER LIMIT	.04	.2 M	.23 M	.19 - .27
5	UPPER LIMIT	.3	1 M	.67 M	.40 - .94

DOT ASSESSMENT RESULTS

EVENT: VIIC07 A vane shear and cone penetrometer that can measure the bottom and sub-bottom seidment shear strength to a sediment depth of 10 ft, range 0.1 to 10 psi, resolution ± 0.1 psi, and can function in ocean depths down to 20,000 ft.

SYSTEM CRITICALITY

N= 5	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL	14		Δ	0 %	
DESIRABLE		14	Δ	100 %	DESIRABLE
UNNECESSARY			Δ	0 %	

DEGREE OF RISK

N= 5	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE		3	Δ	60 %	.1
.4 EXPERIMENTAL	3		Δ	40 %	
.7 SIMULATION			Δ	0 %	
.9 UNPROVEN			Δ	0 %	

DESIRED COURSE OF ACTION

N= 5	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL	20		Δ	40 %	
MEDIUM		40	Δ	60 %	MEDIUM
LONG	20		Δ	0 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
5	EARLIEST	o-o	.4	73	73.2	1 - 1 1/2 YRS.
5	MOST LIKELY	o-o	.4	75	75.2	3 - 3 1/2 YRS.
5	NOT LATER THAN	o--o	.8	77,78	77.8	5 - 6 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
5	LOWER LIMIT	.06	.1 M	.13 M	.07 - .19
5	UPPER LIMIT	.3	None M	.64 M	.34 - .94

DOT ASSESSMENT RESULTS

EVENT: VIIC08 A vane shear and cone penetrometer that can measure the bottom and sub-bottom sediment shear strength to a sediment depth of 100 ft,...same as VIIC07.

SYSTEM CRITICALITY

N = 5	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL			0 %	
DESIRABLE	23		20 %	
UNNECESSARY		23	80 %	UNNECESSARY

DEGREE OF RISK

N = 4	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL			25 %	
.7 SIMULATION		25	75 %	.7
.9 UNPROVEN	25		0 %	

DESIRED COURSE OF ACTION

N = 4	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			0 %	
MEDIUM			75 %	MEDIUM
LONG		25	25 %	
UNDESIRABLE	25		0 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
4	EARLIEST	.5	74.75	74.5	2 - 3 YRS
4	MOST LIKELY	.8	76	76.75	4 - 5 1/2 YRS
4	NOT LATER THAN	1.5	None	79.75	6 - 9 1/2 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
4	LOWER LIMIT	.07	None M	.29 M	.20 - .37
4	UPPER LIMIT	.6	None M	1.23 M	.53 - 1.92

DOT ASSESSMENT RESULTS

EVENT: VIIC09 A direct shear device that can measure...same as VIIC08.

SYSTEM CRITICALITY

N· 4	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %		CONCLUSION
ESSENTIAL			0	0 %	
DESIRABLE	17		0	0 %	
UNNECESSARY		17	100	100 %	UNNECESSARY

DEGREE OF RISK

N· 1	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %		CONCLUSION
.1 PROTOTYPE			0	0 %	
.4 EXPERIMENTAL			0	0 %	
.7 SIMULATION			0	0 %	
.9 UNPROVEN			100	100 %	.9

DESIRED COURSE OF ACTION

N· 1	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %		CONCLUSION
SHORT RANGE GOAL			0	0 %	
MEDIUM			0	0 %	
LONG			0	0 %	
UNDESIRABLE			100	100 %	UNDESIRABLE

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL)	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
1	EARLIEST	72	0	None	74	2 YRS.
1	MOST LIKELY	72	0	None	76	4 YRS
1	NOT LATER THAN	72	0	None	78	6 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
2	LOWER LIMIT	.3	NoneM	.65 M	0 - 2.21
2	UPPER LIMIT	4.7	NoneM	5.3 M	0 - 26.28

DOT ASSESSMENT RESULTS

EVENT: VIIC10 A self-contained recording current meter using an electromagnetic flux sensing techniuqe without moving parts capable of threshold readings at 0.01 kts from 0 to 20,000-ft. ocean depths.

SYSTEM CRITICALITY

N= 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)	%	CONCLUSION
ESSENTIAL		12	Δ	50 %	ESSENTIAL
DESIRABLE	12		Δ	50 %	
UNNECESSARY			Δ	0 %	

DEGREE OF RISK

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)	%	CONCLUSION
.1 PROTOTYPE		12	Δ	27 %	
.4 EXPERIMENTAL	1		Δ	46 %	.4
.7 SIMULATION	11		Δ	27 %	
.9 UNPROVEN			Δ	0 %	

DESIRED COURSE OF ACTION

N= 11	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)	%	CONCLUSION
SHORT RANGE GOAL	3		Δ	64 %	SHORT
MEDIUM		2	Δ	27 %	
LONG		1	Δ	9 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

N		72 73.5 75 76.5 78 81 84 87 90 93 96 00	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	o---o	1.5	75	74.3	1 1/2 - 3 YRS
11	MOST LIKELY	o--o	1.9	75	76.1	3 - 5 YRS
11	NOT LATER THAN	o---o	2.9	78	78.6	5 - 8 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	.2	.5 M	.26 M	.16 - .36
11	UPPER LIMIT	.8	1 M	.85 M	.41 - 1.30

DOT ASSESSMENT RESULTS

EVENT: VIIC11 A self-contained recording current meter using an acoustic doppler flow echo sensing technique...same as VIIC10.

SYSTEM CRITICALITY

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL		1	10 %	
DESIRABLE	2		80 %	DESIRABLE
UNNECESSARY		1	10 %	

DEGREE OF RISK

N= 10	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE	5		20 %	
.4 EXPERIMENTAL		7	40 %	.4
.7 SIMULATION	5		20 %	
.9 UNPROVEN		3	20 %	

DESIRED COURSE OF ACTION

N= 8	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	14.5		12.5 %	
MEDIUM		7.5	62.5 %	MEDIUM
LONG		25	25 %	
UNDESIRABLE	18		0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL)	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST		1.0	75	74.3	1 1/2 - 3 YRS
8	MOST LIKELY		1.2	76	76.4	3 1/2 - 5 YRS
9	NOT LATER THAN		1.8	80	79.2	6 - 8 1/2 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
8	LOWER LIMIT	.1	.5 M	.36 M	.26 - .46
8	UPPER LIMIT	1.4	1 M	1.28 M	.32 - 2.24

DOT ASSESSMENT RESULTS

EVENT: VIIC12 A self-contained recording current meter using a nuclear spin echo sensing technique capable of...same as VIIC 10.

SYSTEM CRITICALITY

N= 7	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL			0 %	
DESIRABLE	13		43 %	
UNNECESSARY		13	57 %	UNNECESSARY

DEGREE OF RISK

N= 6	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL			0 %	
.7 SIMULATION		8	33 %	
.9 UNPROVEN	8		67 %	.9

DESIRED COURSE OF ACTION

N= 6	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			0 %	
MEDIUM	12		17 %	
LONG		21	50 %	LONG
UNDESIRABLE	9		33 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
5	EARLIEST	.8	75,76	75.2	2 1/2 - 4 YRS
5	MOST LIKELY	1.5	77	77.8	4 1/2 - 7 YRS
5	NOT LATER THAN	2.6	None	81.4	7 - 12 YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
6	LOWER LIMIT	.3	.3,1 M	.56 M	.29 - .83
6	UPPER LIMIT	3.4	1,5 M	3.75 M	.98 - 6.52

APPENDIX H

TECHNOLOGY AREA VIII. LOAD HANDLING AND TRANSPORTATION

SUB-TECHNOLOGY AREAS:

A. Near Bottom Transport and Positioning
B. Guidance
C. Lifting and Lowering

VIIIA Sub-Technology: Near Bottom Transport and Positioning

Objective: To develop the technologies necessary to accurately position heavy loads on the bottom in accordance with the following minimum specifications:

O	Depth	8,000 ft
O	Load capacity	30 tons (submerged weight)
O	Transport capability	600 ft
O	Alignment tolerance (translational)	0.5 ft
O	Alignment tolerance (rotational)	3 degrees
O	Attitude tolerance (vertical)	3 degrees
O	Minimum ocean current tolerance	2 knots

Events VIIIA01 - VIIIA06 address this objective.

DOT ASSESSMENT RESULTS

EVENT: VIIIA01 — An underwater bottom resting crane, using an underwater winch and cables, capable of lifting a 30-ton load to a height of 100 ft off the seafloor, transporting it 600 ft across the bottom and positioning the load with the use of a guidance system in an exact predetermined position.

SYSTEM CRITICALITY

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL			Δ	0 %	
DESIRABLE	21		Δ	20 %	
UNNECESSARY		21	Δ	80 %	UNNECESSARY

DEGREE OF RISK

N= 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL			Δ	7 %	
.7 SIMULATION		5	Δ	71 %	.7
.9 UNPROVEN	5		Δ	22 %	

DESIRED COURSE OF ACTION

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL	6		Δ	0 %	
MEDIUM	6		Δ	7 %	
LONG		2	Δ	27 %	
UNDESIRABLE		10	Δ	66 %	UNDESIRABLE

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	o-o	1.4	80	78.75	6 - 7½ YRS
12	MOST LIKELY	o-o	2.1	85	82.75	9½ - 12 YRS
12	NOT LATER THAN	o-o	3.3	90	87.9	14 - 17½ YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
12	LOWER LIMIT	11.6	10 M	17.7 M	11.6 - 23.7
12	UPPER LIMIT	26.9	50 M	58.0 M	44.07 - 71.93

DOT ASSESSMENT RESULTS

EVENT: VIIIA02 An underwater, bottom resting, mechanical lifting system (e.g., fork lift device) capable of lifting ... same as VIIIA01.

SYSTEM CRITICALITY

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL			Δ	0 %	
DESIRABLE	22		Δ	7 %	
UNNECESSARY		22	Δ	93 %	UNNECESSARY

DEGREE OF RISK

N= 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL	7		Δ	0 %	
.7 SIMULATION		3	Δ	36 %	
.9 UNPROVEN		4	Δ	64 %	.9

DESIRED COURSE OF ACTION

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL	6		Δ	0 %	
MEDIUM		1	Δ	7 %	
LONG			Δ	13 %	
UNDESIRABLE		5	Δ	80 %	UNDESIRABLE

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
12	EARLIEST	o–o	1.8	80	78.1	5 - 7 YRS.
12	MOST LIKELY	o–o	2.2	85	82.4	9½ - 11½ YRS.
12	NOT LATER THAN	o--o	3.4	90	87.7	14 - 17½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
12	LOWER LIMIT	11.7	15 M	16.58M	10.49 - 22.67
12	UPPER LIMIT	27.8	50 M	53.08M	38.65 - 67.52

DOT ASSESSMENT RESULTS

EVENT: VIIIA03 An underwater near-bottom propulsion lifting system (e.g., near-bottom sea helicopter) capable of lifting ... same as VIIIA01.

SYSTEM CRITICALITY

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	5		7 %	
DESIRABLE		11	40 %	
UNNECESSARY	6		53 %	UNNECESSARY

DEGREE OF RISK

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL		1	7 %	
.7 SIMULATION	4		40 %	
.9 UNPROVEN		3	53 %	.9

DESIRED COURSE OF ACTION

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	12		0 %	
MEDIUM		8	20 %	
LONG		6	47 %	LONG
UNDESIRABLE	2		33 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

72 73.5 75 76.5 78 81 84 87 90 93 96 99

N		CALENDAR YEARS	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
13	EARLIEST	o--o	1.9	80	77.5	4½ - 6½ YRS
13	MOST LIKELY	o--o	2.8	80	81.3	8 - 10½ YRS
13	NOT LATER THAN	o-o	3.2	85	85.8	12 - 15½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
13	LOWER LIMIT	8.2	5 M	14.00M	9.92 - 18.08
13	UPPER LIMIT	31.3	20/50M	50.69M	35.22 - 66.17

DOT ASSESSMENT RESULTS

EVENT: VIIIA04 An underwater near-bottom buoyancy control lifting system, using propulsive power for movement (i.e., waterjets, propellers, etc), and chemical gas generation for buoyancy capable of lifting ... same as VIIIA01.

SYSTEM CRITICALITY

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL		1	60 %	ESSENTIAL
DESIRABLE	1		40 %	
UNNECESSARY			0 %	

DEGREE OF RISK

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL		11	93 %	.4
.7 SIMULATION	11		7 %	
.9 UNPROVEN			0 %	

DESIRED COURSE OF ACTION

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		14	73 %	SHORT
MEDIUM	3		20 %	
LONG	11		7 %	
UNDESIRABLE			0 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
15	EARLIEST	.7	75	75.1	3 - 3½ YRS.
15	MOST LIKELY	1.5	80	78.3	5½ - 7 YRS
15	NOT LATER THAN	2.3	80	81.6	8½ - 10½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
15	LOWER LIMIT	4.7	10 M	7.97M	5.81 - 10.12
15	UPPER LIMIT	14.1	25 M	28.00M	21.57 - 34.43

DOT ASSESSMENT RESULTS

EVENT: VIIIA05 An underwater near-bottom buoyancy control lifting system, using propulsive power for movement (i.e., waterjets, propellers, etc), and a seawater ballast pumping system for buoyancy capable of lifting ... same as VIIIA01.

SYSTEM CRITICALITY

	PERCENTAGE		FINAL CONSENSUS %		
N= 15	LOSS	GAIN	0 25 50 75 100		CONCLUSION
ESSENTIAL	12		Δ	0 %	
DESIRABLE		11	Δ	87 %	DESIRABLE
UNNECESSARY		1	Δ	13 %	

DEGREE OF RISK

	PERCENTAGE		FINAL CONSENSUS %		
N= 14	LOSS	GAIN	0 25 50 75 100		CONCLUSION
.1 PROTOTYPE	9.5		Δ	14 %	
.4 EXPERIMENTAL		2	Δ	43 %	.4
.7 SIMULATION		12.5	Δ	36 %	
.9 UNPROVEN	5		Δ	7 %	

DESIRED COURSE OF ACTION

	PERCENTAGE		FINAL CONSENSUS %		
N= 15	LOSS	GAIN	0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL		1	Δ	20 %	
MEDIUM		10	Δ	60 %	MEDIUM
LONG	12		Δ	13 %	
UNDESIRABLE		1	Δ	7 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
15	EARLIEST	o---o	2.8	75/76	76.7	3½ - 6 YRS.
15	MOST LIKELY	o--o	3.4	80	80.1	6½ - 9½ YRS
15	NOT LATER THAN	o-o	4.3	82	84.0	10 - 14 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
15	LOWER LIMIT	5.2	5 M	8.73M	6.35 - 11.12
15	UPPER LIMIT	17.0	10 M	27.67M	19.93 - 35.40

DOT ASSESSMENT RESULTS

EVENT: VIIIA06 An underwater near-bottom buoyancy control lifting system, using propulsive power for movement (i.e., waterjets, propellers, etc), and a non-seawater fluid and expandable bladder system for buoyancy capable of lifting --- same as VIIIA01.

SYSTEM CRITICALITY

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL			Δ	0 %	
DESIRABLE			Δ	53 %	DESIRABLE
UNNECESSARY			Δ	47 %	

DEGREE OF RISK

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE	18		Δ	13 %	
.4 EXPERIMENTAL		7	Δ	13 %	
.7 SIMULATION		23	Δ	67 %	.7
.9 UNPROVEN	12		Δ	7 %	

DESIRED COURSE OF ACTION

N= 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL		1	Δ	7 %	
MEDIUM	17		Δ	21 %	
LONG		15	Δ	21 %	
UNDESIRABLE		1	Δ	51 %	UNDESIRABLE

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
15	EARLIEST	o---o	3.5	78	78.1	4½ - 7½ YRS.
15	MOST LIKELY	o----o	4.2	80	81.8	8 - 11½ YRS.
15	NOT LATER THAN	o--o	4.9	85	86.2	12 - 16½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
15	LOWER LIMIT	10.0	10 M	14.40M	9.86 - 18.94
15	UPPER LIMIT	28.2	50 M	46.33M	33.51 - 59.15

VIIIB Sub-Technology: <u>Guidance</u>

<u>Objective:</u> To develop the technology necessary to provide guidance to loads being lowered or raised at 8,000-ft ocean depths in order to accurately control the ascent and descent to a predetermined position, and a near bottom guidance system for positioning loads being moved across the seafloor to a predetermined position.

Events VIIIB01 - VIIIB10 address this objective.

DOT ASSESSMENT RESULTS

EVENT: VIIIB01

A guidance system using taut anchored flexible guidelines for controlling the attitude of a 600-ton (submerged weight) load during ascent or descent from the surface down to 8,000-ft ocean depths. The guidance system is capable of exact positioning of the load to ± 1 ft in the desired attitude at a predetermined position on the seafloor.

SYSTEM CRITICALITY

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL		2	Δ	15 %	
DESIRABLE		5	Δ	38 %	
UNNECESSARY	7		Δ	47 %	UNNECESSARY

DEGREE OF RISK

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE		1	Δ	8 %	
.4 EXPERIMENTAL		2	Δ	23 %	
.7 SIMULATION	14		Δ	15 %	
.9 UNPROVEN		11	Δ	54 %	.9

DESIRED COURSE OF ACTION

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL		2	Δ	15 %	
MEDIUM		2	Δ	15 %	
LONG		6	Δ	47 %	LONG
UNDESIRABLE	10		Δ	23 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
13	EARLIEST	o-- o	2.0	75	75.5	2½ - 4½ YRS.
13	MOST LIKELY	o--o	2.2	78	78.9	6 - 8 YRS.
13	NOT LATER THAN	o- o	2.7	80	82.1	9 - 11½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
13	LOWER LIMIT	27.1	10 M	24.00M	10.59 - 37.41
13	UPPER LIMIT	132.9	10 M	93.85M	28.18 - 159.51

DOT ASSESSMENT RESULTS

EVENT: VIIIB02 A guidance system using rigid members for controlling ... same as VIIIB01.

SYSTEM CRITICALITY

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL		8	Δ	15 %	
DESIRABLE			Δ	0 %	
UNNECESSARY	8		Δ	85 %	UNNECESSARY

DEGREE OF RISK

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE		9	Δ	17 %	
.4 EXPERIMENTAL			Δ	0 %	
.7 SIMULATION	15		Δ	8 %	
.9 UNPROVEN		6	Δ	75 %	.9

DESIRED COURSE OF ACTION

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL		8	Δ	15 %	
MEDIUM	7		Δ	0 %	
LONG		8	Δ	15 %	
UNDESIRABLE	9		Δ	70 %	UNDESIRABLE

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
11	EARLIEST	o--- o	2.1	75	75.8	2½ - 5 YRS.
11	MOST LIKELY	o--o	2.6	80	79.5	6 - 9 YRS.
11	NOT LATER THAN	o--o	3.5	85	83.4	9½ - 13½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	27.7	35 M	30.0M	14.92 - 45.17
11	UPPER LIMIT	137.4	50/100 M	113.7M	38.67 - 188.78

DOT ASSESSMENT RESULTS

EVENT: VIIIB03 A guidance system tethered (slack hard wire) for positioning and attitude control of a propulsion system (e.g., thrusters, propellers) attached to the load, for controlling ... same as VIIIB01.

SYSTEM CRITICALITY

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL			0 %	
DESIRABLE		7	54 %	DESIRABLE
UNNECESSARY	7		46 %	

DEGREE OF RISK

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL	7		0 %	
.7 SIMULATION		13	85 %	.7
.9 UNPROVEN	8		15 %	

DESIRED COURSE OF ACTION

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			0 %	
MEDIUM	12		38 %	
LONG		24	38 %	LONG
UNDESIRABLE	12		24 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

72 73.5 75 76.5 78 81 84 87 90 93 96 99

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
13	EARLIEST	1.1	75	75.5	3 - 4 YRS.
13	MOST LIKELY	1.9	80	79.4	6½ - 8½ YRS.
13	NOT LATER THAN	2.2	85	83.6	10½ - 12½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
13	LOWER LIMIT	12.5	10 M	14.77M	8.61 - 20.93
13	UPPER LIMIT	26.2	16,25 M	39.23M	26.27 - 52.19

DOT ASSESSMENT RESULTS

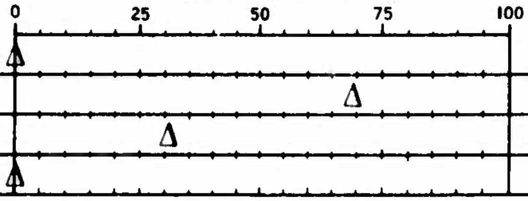
EVENT: VIIIB04 A guidance system using acoustic transmission for positioning and remote control of an attitude control propulsion system (e.g., thrusters, propellers) attached to the load for controlling ... same as VIIIB01.

SYSTEM CRITICALITY

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	12		8 %	
DESIRABLE		12	92 %	DESIRABLE
UNNECESSARY			0 %	

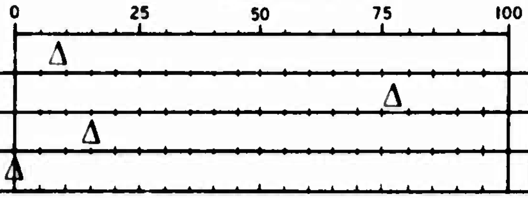
DEGREE OF RISK

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE	7		0 %	
.4 EXPERIMENTAL		19	69 %	.4
.7 SIMULATION	12		31 %	
.9 UNPROVEN			0 %	



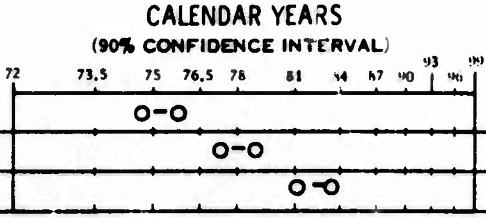
DESIRED COURSE OF ACTION

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	7		8 %	
MEDIUM			77 %	MEDIUM
LONG		7	15 %	
UNDESIRABLE			0 %	



PROBABLE TIMING

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
13	EARLIEST	1.1	75	75.5	3 - 4 YRS.
13	MOST LIKELY	1.7	80	78.5	5½ - 7½ YRS
13	NOT LATER THAN	2.2	82	82.1	9 - 11 YRS.



ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
13	LOWER LIMIT	11.7	5 M	11.00M	5.24 - 16.76
13	UPPER LIMIT	22.7	20/25M	29.23M	18.02 - 40.44

DOT ASSESSMENT RESULTS

EVENT: VIIIB05 A guidance system using an automated acoustic system (i.e., positioning by pinging a reference reflector or transponder) for direct control of a propulsion system, attached to the load, for controlling ... same as VIIIB01.

SYSTEM CRITICALITY

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL	7		Δ	0 %	
DESIRABLE		7	Δ	100 %	DESIRABLE
UNNECESSARY			Δ	0 %	

DEGREE OF RISK

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE	13		Δ	0 %	
.4 EXPERIMENTAL		29	Δ	68 %	.4
.7 SIMULATION	9		Δ	31 %	
.9 UNPROVEN	7		Δ	0 %	

DESIRED COURSE OF ACTION

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL	15		Δ	0 %	
MEDIUM		15	Δ	85 %	MEDIUM
LONG			Δ	15 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
13	EARLIEST	o--o	1.5	75	75.8	3 - 4½ YRS.
13	MOST LIKELY	o-o	2.3	78	78.8	5½ - 8 YRS.
13	NOT LATER THAN	o- o	2.9	82	82.5	9 - 12 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
13	LOWER LIMIT	4.1	10 M	8.92M	6.90 - 10.94
13	UPPER LIMIT	13.9	20 M	25.92M	19.05 - 32.79

DOT ASSESSMENT RESULTS

EVENT: VIIIB06 A guidance system using a laser beam as a reference to exercise direct control of a propulsion system, attached to the load, for controlling ... same as VIIIB01.

SYSTEM CRITICALITY

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL			0 %	
DESIRABLE	12		15 %	
UNNECESSARY		12	85 %	UNNECESSARY

DEGREE OF RISK

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL	7		0 %	
.7 SIMULATION	13		8 %	
.9 UNPROVEN		20	92 %	.9

DESIRED COURSE OF ACTION

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	7		0 %	
MEDIUM		1	8 %	
LONG	14		15 %	
UNDESIRABLE		20	77 %	UNDESIRABLE

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	1.6	80	78.6	5½ - 7½ YRS
10	MOST LIKELY	2.1	85	82.5	9½ - 11½ YRS.
10	NOT LATER THAN	2.8	85/90	86.8	13 - 16½ YRS.

ESTIMATED COSTS TO ACHIEVE

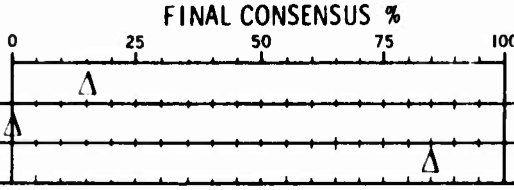
N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	6.4	10 M	13.20M	9.48 - 16.92
10	UPPER LIMIT	25.5	50 M	47.60M	32.79 - 62.41

DOT ASSESSMENT RESULTS

EVENT: VIIIB07 — An underwater near-bottom guidance system, using rigid guide rails, in conjunction with a near-bottom lifting device capable of positioning a large object with an alignment tolerance of ± 0.5 ft translational, ± 1 degree rotational (vertical axis), and ± 1 ft rotational (horizontal axis).

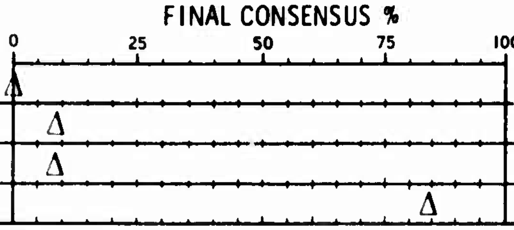
SYSTEM CRITICALITY

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	5		15 %	
DESIRABLE	13		0 %	
UNNECESSARY		18	85 %	UNNECESSARY



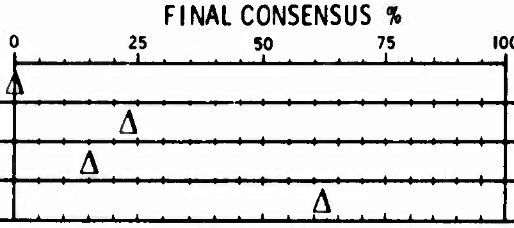
DEGREE OF RISK

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE	7		0 %	
.4 EXPERIMENTAL	6		8 %	
.7 SIMULATION		1	8 %	
.9 UNPROVEN		12	84 %	.9



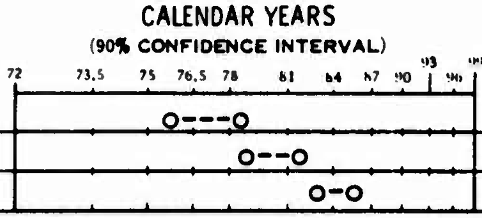
DESIRED COURSE OF ACTION

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	20		0 %	
MEDIUM		3	23 %	
LONG		2	15 %	
UNDESIRABLE		15	62 %	UNDESIRABLE



PROBABLE TIMING

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	2	78	77.2	4 - 6½ YRS.
10	MOST LIKELY	2.5	80	80.4	7 - 10 YRS.
10	NOT LATER THAN	3.2	85	84.3	10½ - 14 YRS.



ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	13.4	2 M	13.80M	6.02 - 21.58
10	UPPER LIMIT	23.6	25 M	36.00M	22.30 - 49.70

DOT ASSESSMENT RESULTS

EVENT: VIIIB08 An underwater near-bottom guidance system, using flexible guide wires in conjunction with a near-bottom lifting device capable of positioning ... same as VIIIB07.

SYSTEM CRITICALITY

N= 13	PERCENTAGE LOSS	 GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL		2	Δ	15%	
DESIRABLE	19		Δ	8%	
UNNECESSARY		17	Δ	77%	UNNECESSARY

DEGREE OF RISK

N= 12	PERCENTAGE LOSS	 GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE			Δ	0%	
.4 EXPERIMENTAL	6		Δ	8%	
.7 SIMULATION	12		Δ	17%	
.9 UNPROVEN		18	Δ	75%	.9

DESIRED COURSE OF ACTION

N= 13	PERCENTAGE LOSS	 GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL		1	Δ	15%	
MEDIUM	13		Δ	8%	
LONG		8	Δ	15%	
UNDESIRABLE		4	Δ	62%	UNDESIRABLE

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	o-- o	2.2	76,78	77.0	3½ - 6½ YRS.
10	MOST LIKELY	o---o	3.5	80	81.4	7½ - 11½YRS
10	NOT LATER THAN	o-- o	4.4	85	85.0	10½ - 15½YRS

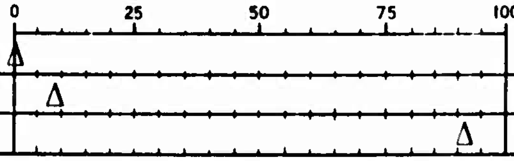
ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	3.3	10 M	8.80M	6.90 - 10.70
10	UPPER LIMIT	12.1	30 M	26.90M	19.91 - 33.89

DOT ASSESSMENT RESULTS

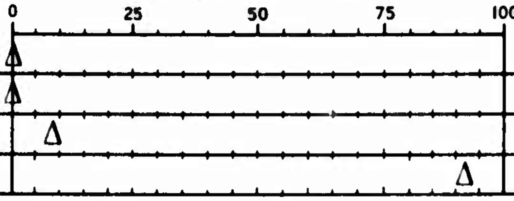
EVENT: VIIIB09 An underwater near-bottom guidance system, using a laser beam directional system, in conjunction with a near-bottom lifting device capable of positioning ... same as VIIIB07.

SYSTEM CRITICALITY



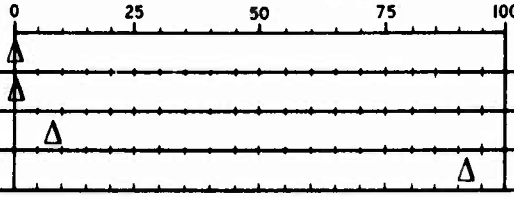
N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	7		0 %	
DESIRABLE	12		8 %	
UNNECESSARY		19	92 %	UNNECESSARY

DEGREE OF RISK



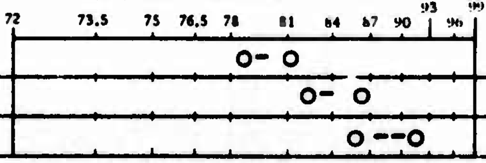
N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE	7		0 %	
.4 EXPERIMENTAL			0 %	
.7 SIMULATION	6		8 %	
.9 UNPROVEN		13	92 %	.9

DESIRED COURSE OF ACTION



N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			0%	
MEDIUM	29		0%	
LONG		1	8%	
UNDESIRABLE		28	92%	UNDESIRABLE

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
10	EARLIEST	2.8	80	80.0	6½ - 9½ YRS.
10	MOST LIKELY	3.5	85	84.4	10½ - 14½ YRS.
10	NOT LATER THAN	4.3	90	88.6	14 - 19 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
10	LOWER LIMIT	13.7	15 M	20.60M	12.65 - 28.55
10	UPPER LIMIT	32.3	80 M	53.50M	34.80 - 72.20

DOT ASSESSMENT RESULTS

EVENT: VIIIB10 An anti-rotation system for preventing a suspended load from spinning or turning while it is being lowered from a surface ship to the ocean floor in water depths to 8,000 ft. The device would also monitor and control the orientation of the suspended load.

SYSTEM CRITICALITY

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL		18	85 %	ESSENTIAL
DESIRABLE	5		15 %	
UNNECESSARY	13		0 %	

DEGREE OF RISK

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE		9	38 %	
.4 EXPERIMENTAL		1	8 %	
.7 SIMULATION	3		54 %	.7
.9 UNPROVEN	7		0 %	

DESIRED COURSE OF ACTION

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL		17	84 %	SHORT
MEDIUM	14		8 %	
LONG	3		8 %	
UNDESIRABLE			0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
13	EARLIEST	o--o	1.6	74	74.2	1½ - 3 YRS.
13	MOST LIKELY	o- o	1.9	75	76.6	3½ - 5½ YRS.
13	NOT LATER THAN	o---o	3.2	76	79.5	6 - 9 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
13	LOWER LIMIT	2.5	1.2 M	2.68M	1.43 - 3.93
13	UPPER LIMIT	12.2	10 M	10.14M	4.12 - 16.15

VIIIC Sub-Technology: <u>Lifting and Lowering</u>

<u>Objective:</u> To develop the technology necessary to design systems (multiple or single) that can lower and lift loads of 300 to 600 tons (submerged weight) to 12,000-ft ocean depths with a lifting/lowering rate of 4 ft/second and a maximum vertical oscillation of 1.0 in a Sea State 4 condition.

Events VIIIC01 - VIIIC07 address this objective.

DOT ASSESSMENT RESULTS

EVENT: VIIIC01 A surface platform winch system, using single or multiple lifting lines as required, and having vertical motion compensation, capable of lifting and lowering loads of 600 tons down to 8,000-ft ocean depths. The system is capable of a lifting rate of 4 ft per second while allowing only a maximum vertical oscillation of 1.0 ft in a Sea State 4 condition.

SYSTEM CRITICALITY

N- 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL		6	Δ	47 %	ESSENTIAL
DESIRABLE		16	Δ	40 %	
UNNECESSARY	22		Δ	13 %	

DEGREE OF RISK

N- 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE	5.5		Δ	7 %	
.4 EXPERIMENTAL		22	Δ	53 %	.4
.7 SIMULATION	5.5		Δ	7 %	
.9 UNPROVEN	11		Δ	33 %	

DESIRED COURSE OF ACTION

N- 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL	5		Δ	33 %	
MEDIUM		23	Δ	54 %	MEDIUM
LONG			Δ	0 %	
UNDESIRABLE	18		Δ	13 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 64 67 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
13	EARLIEST	o--o	1.5	75	75.9	3 - 4½ YRS.
13	MOST LIKELY	o-o	2.0	80	79.6	6½ - 8½ YRS.
13	NOT LATER THAN	o- o	3.0	85	83.5	10 - 13 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
13	LOWER LIMIT	13.8	20 M	2.31M	16.25 - 29.90
13	UPPER LIMIT	36.3	50 M	73.85M	55.92 - 91.76

DOT ASSESSMENT RESULTS

EVENT: VIIIC02 A water sheel type winch (hydrodynamic winch) system, using single or multiple lifting lines as required and having vertical motion compensation, capable of lifting ... same as VIIIC01.

SYSTEM CRITICALITY

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL	6		Δ	0 %	
DESIRABLE	15		Δ	8 %	
UNNECESSARY		21	Δ	92 %	UNNECESSARY

DEGREE OF RISK

N= 12	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE	6		Δ	0 %	
.4 EXPERIMENTAL	13		Δ	0 %	
.7 SIMULATION		2	Δ	33 %	
.9 UNPROVEN		17	Δ	67 %	.9

DESIRED COURSE OF ACTION

N= 13	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL			Δ	0 %	
MEDIUM	7		Δ	0 %	
LONG	9		Δ	31 %	
UNDESIRABLE		16	Δ	69 %	UNDESIRABLE

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) (72 73.5 75 76.5 78 81 84 87 90 93 96 99)	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
9	EARLIEST	o---o	3.9	78	80.7	6 - 11 YRS.
9	MOST LIKELY	o-+--o	4.8	82	84.4	9½ - 15½ YRS.
9	NOT LATER THAN	o--o	5.2	85/90	89.1	14 - 20½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
9	LOWER LIMIT	26.5	50 M	38.78 M	22.36 - 55.19
9	UPPER LIMIT	55.1	150 M	107.22 M	73.04 - 141.40

DOT ASSESSMENT RESULTS

EVENT: VIIIC03 A surface winch system, using single or multiple lifting lines as required, and mounted on a minimum response surface platform (e.g., mass traps), capable of lifting ... same as VIIIC01.

SYSTEM CRITICALITY

Nº 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	5		13 %	
DESIRABLE		14	67 %	DESIRABLE
UNNECESSARY	9		20 %	

DEGREE OF RISK

Nº 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL		2.5	40 %	.4
.7 SIMULATION		2.5	40 %	.7
.9 UNPROVEN	5		20 %	

DESIRED COURSE OF ACTION

Nº 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	6		0 %	
MEDIUM		17	73 %	MEDIUM
LONG	6		7 %	
UNDESIRABLE	5		20 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
13	EARLIEST	1.7	75	76.8	4 - 5½ YRS.
13	MOST LIKELY	2.3	80	80.2	7 - 9½ YRS.
13	NOT LATER THAN	3.0	82/85	84.0	10½ - 13½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
13	LOWER LIMIT	12.7	20 M	22.08M	15.79 - 28.36
13	UPPER LIMIT	27.5	50/100M	65.77M	52.17 - 79.37

DOT ASSESSMENT RESULTS

EVENT: VIIIC04 A buoyancy controlled lifting system using controlled (remote or tethered) seawater pumping from a rigid pontoon, capable of lifting or lowering 300-ton loads down to 800-ft ocean depths. The system is capable of lifting at a controlled rate.

SYSTEM CRITICALITY

N: 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	15		20 %	
DESIRABLE		14	67 %	DESIRABLE
UNNECESSARY		1	13 %	

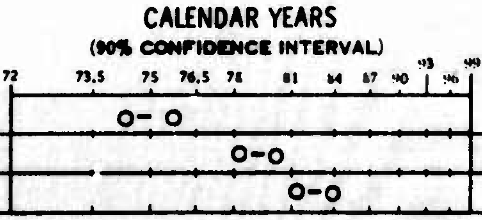
DEGREE OF RISK

N: 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE	5.5		7 %	
.4 EXPERIMENTAL	16.5		21 %	
.7 SIMULATION		22	72 %	.7
.9 UNPROVEN			0 %	

DESIRED COURSE OF ACTION

N: 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	4.5		33 %	
MEDIUM		16.5	54 %	MEDIUM
LONG	12.5		0 %	
UNDESIRABLE		1	13 %	

PROBABLE TIMING



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
15	EARLIEST	1.1	75	75.2	2½ - 3½ YRS.
15	MOST LIKELY	1.5	80	79.0	6½ - 7½ YRS.
15	NOT LATER THAN	2.4	83/85	82.6	9½ - 11½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
15	LOWER LIMIT	6.9	5 M	9.43 M	5.37 - 13.49
15	UPPER LIMIT	17.1	10/20M	20.87M	13.07 - 28.66

DOT ASSESSMENT RESULTS

EVENT: VIIIC05 A buoyancy controlled lifting system using controlled gas generation from liquid nitrogen dewars for dewatering rigid pontoons, capable of lifting and lowering 300 ton loads down to 2,500-ft ocean depths. The system is capable of ... same as VIIC04.

SYSTEM CRITICALITY

N• 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL	12		Δ	0 %	
DESIRABLE		10	Δ	80 %	DESIRABLE
UNNECESSARY		2	Δ	20 %	

DEGREE OF RISK

N• 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE	12		Δ	0 %	
.4 EXPERIMENTAL		1	Δ	36 %	
.7 SIMULATION		14	Δ	43 %	.7
.9 UNPROVEN	3		Δ	21 %	

DESIRED COURSE OF ACTION

N• 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL	8		Δ	27 %	
MEDIUM		9	Δ	33 %	MEDIUM
LONG	2		Δ	27 %	
UNDESIRABLE		1	Δ	13 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
14	EARLIEST	o--o	2.6	75	76.4	3 - 5½ YRS.
14	MOST LIKELY	o--o	2.9	80	80.4	7 - 10 YRS
14	NOT LATER THAN	o--o	3.5	85	84.4	10½ - 14 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
14	LOWER LIMIT	5.9	10 M	11.29M	8.49 - 14.08
14	UPPER LIMIT	9.7	30 M	26.57M	22.00 - 31.18

DOT ASSESSMENT RESULTS

EVENT: VIIIC06 A buoyancy controlled lifting system using controlled gas generation by Hydrazine decomposition (catalitic reactor) for dewatering rigid pontoons, capable of lifting or lowering 300-ton loads down to 12,000-ft ocean depths. The system is capable of ... same as VIIIC04.

SYSTEM CRITICALITY

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL	6		Δ	0 %	
DESIRABLE		11	Δ	87 %	DESIRABLE
UNNECESSARY	5		Δ	13 %	

DEGREE OF RISK

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE	6		Δ	0 %	
.4 EXPERIMENTAL		7.5	Δ	20 %	
.7 SIMULATION	2		Δ	67 %	.7
.9 UNPROVEN		.5	Δ	13 %	

DESIRED COURSE OF ACTION

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL	12		Δ	7 %	
MEDIUM		9	Δ	53 %	MEDIUM
LONG		2	Δ	27 %	
UNDESIRABLE		1	Δ	13 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
14	EARLIEST	o---o	2.8	75	77.2	4 - 6½ YRS.
14	MOST LIKELY	o- o	3.2	80	81.4	8 - 11 YRS.
14	NOT LATER THAN	o--o	4.5	85	85.8	11½ - 16 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
14	LOWER LIMIT	5.0	10 M	12.36 M	10.00 - 14.73
14	UPPER LIMIT	11.2	30 M	31.43M	26.10 - 36.75

DOT ASSESSMENT RESULTS

EVENT: VIIIC07 A buoyancy controlled lifting system using controlled gas generation for inflation of inflatable pontoons (gas bags) capable of lifting or lowering 10-ton loads down to 8,000-ft ocean depths. The system is capable of ... same as VIIIC04.

SYSTEM CRITICALITY

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL		26	Δ	73%	ESSENTIAL
DESIRABLE	8		Δ	27%	
UNNECESSARY	18		Δ	0%	

DEGREE OF RISK

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE		.5	Δ	13%	
.4 EXPERIMENTAL		18	Δ	74%	.4
.7 SIMULATION	6		Δ	13%	
.9 UNPROVEN	12.5		Δ	0%	

DESIRED COURSE OF ACTION

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL		26	Δ	67%	SHORT
MEDIUM	8		Δ	33%	
LONG			Δ	0	
UNDESIRABLE	18		Δ	0%	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
15	EARLIEST	o--o	2	75	75.6	2½ - 4½ YRS.
15	MOST LIKELY	o-o	2.7	76	78.3	5 - 7½ YRS
15	NOT LATER THAN	o- o	4.0	78/80	81.9	8 - 11½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
15	LOWER LIMIT	3.4	5 M	5.87M	4.32 - 7.41
15	UPPER LIMIT	6.8	15 M	14.40M	11.33 - 17.47

APPENDIX I

TECHNOLOGY AREA IX. LIFE SUPPORT AND RELATED SYSTEMS

SUB-TECHNOLOGY AREA:

A. Life Support and Related Systems

IXA Sub-Technology: Life Support and Related Systems

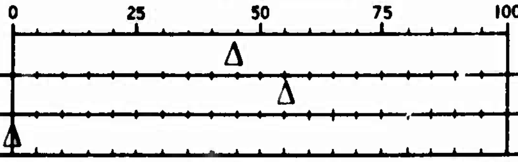
Objective: To advance the technologies necessary to maintain a safe and habitable one-atmosphere environment in a submersible pressure hull for 8 to 10 men for periods up to 30 days .

Events IXA01 - IXA18 address this objective.

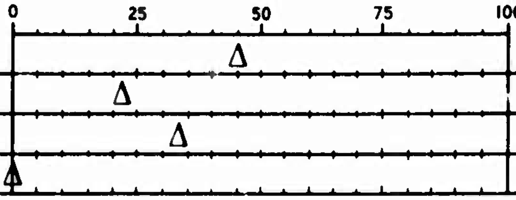
DOT ASSESSMENT RESULTS

EVENT: IXA01 An oxygen supply system for manned deep submergence vehicles using compressed gaseous oxygen providing the requirements of 3 to 10 men for periods of 1 to 30 days. When fully charged the system weighs less than 30 pounds for each 10 lbs of stored oxygen and occupies less than 1.5 cubic feet for each 10 pounds of stored oxygen. Routine maintenance interval is no less than every 30 days and overhaul interval is no less than one year.

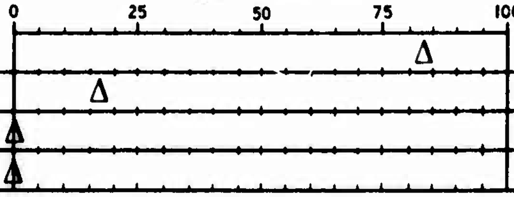
SYSTEM CRITICALITY

N= 18	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %		CONCLUSION
ESSENTIAL	8.5			44.5 %	
DESIRABLE		8.5		55.5 %	DESIRABLE
UNNECESSARY				0 %	

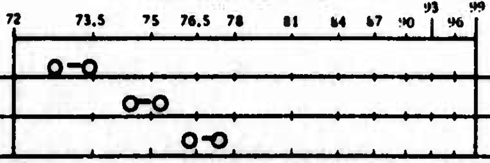
DEGREE OF RISK

N= 18	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %		CONCLUSION
.1 PROTOTYPE		4		45 %	.1
.4 EXPERIMENTAL	2			22 %	
.7 SIMULATION	2			33 %	
.9 UNPROVEN				0 %	

DESIRED COURSE OF ACTION

N= 18	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %		CONCLUSION
SHORT RANGE GOAL		14		83 %	SHORT
MEDIUM	14			17 %	
LONG				0 %	
UNDESIRABLE				0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL)	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
18	EARLIEST		.5	73	73.2	1 - 1½ YRS.
17	MOST LIKELY		.8	75	74.9	2½ - 3 YRS.
17	NOT LATER THAN		.8	76	76.5	4 - 5 YRS.

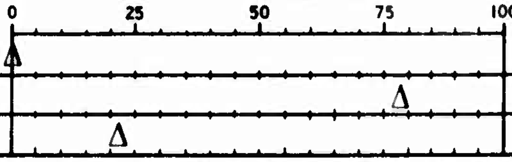
ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
17	LOWER LIMIT	.2	.2 M	.27 M	.18 - .37
17	UPPER LIMIT	.4	1 M	.80 M	.60 - 1.00

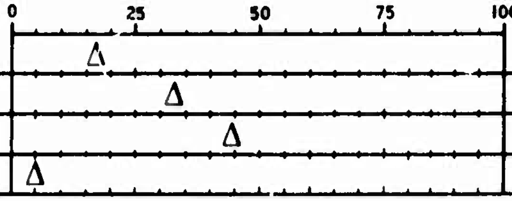
DOT ASSESSMENT RESULTS

EVENT: IXA02 A system as in IXA01 using cryogenic liquid oxygen. When fully charged the system occupies less than 0.7 cubic feet for each 10 pounds of stored oxygen. The normal boil-off rate is less than 10% in 30 days. The system can be completely shut off for periods up to 10 hours without hazard. Routine maintenance is required on a 30-day basis and overhaul interval is required annually.

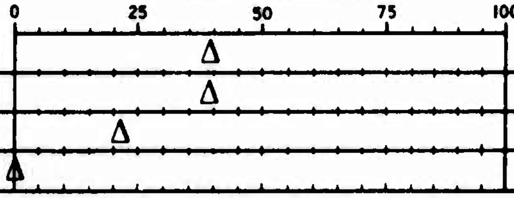
SYSTEM CRITICALITY

N- 18	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL	6			0 %	
DESIRABLE		6		78 %	DESIRABLE
UNNECESSARY				22 %	

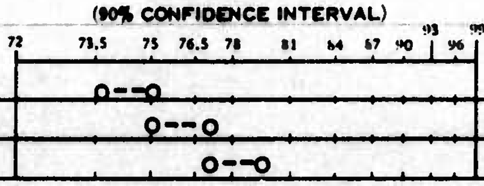
DEGREE OF RISK

N- 18	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE	12			17 %	
.4 EXPERIMENTAL		4		33 %	
.7 SIMULATION		8.5		44.5%	.7
.9 UNPROVEN	.5			5.5%	

DESIRED COURSE OF ACTION

N- 18	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL		1.5		39 %	SHORT
MEDIUM		1.5		39 %	MEDIUM
LONG		3		22 %	
UNDESIRABLE	6			0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
18	EARLIEST		1.7	74	74.3	1½ - 3 YRS.
17	MOST LIKELY		2.0	75/76	76.4	3½ - 5 YRS.
15	NOT LATER THAN		2.4	76/78	77.9	5 - 7 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
17	LOWER LIMIT	.4	.1 M	.52 M	.31 - .72
16	UPPER LIMIT	.9	1 M	1.44M	1.02 - 1.85

DOT ASSESSMENT RESULTS

EVENT: IXA03 A system as in IXA01, using a chemical reaction oxygen generation method. The fully charged system weighs less than 20 pounds per 10 lbs of stored oxygen and occupies less than 0.5 cubic feet for each 10 pounds of stored oxygen and can be stopped and restarted as often as required. Routine maintenance is required on a 30-day basis and overhaul interval is no less than one year.

SYSTEM CRITICALITY

N· 17	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL		6	6 %	
DESIRABLE			94 %	DESIRABLE
UNNECESSARY	6		0 %	

DEGREE OF RISK

N· 16	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE	.5		12.5 %	
.4 EXPERIMENTAL		9	56 %	.4
.7 SIMULATION	1		19 %	
.9 UNPROVEN	7.5		12.5 %	

DESIRED COURSE OF ACTION

N· 17	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	1		12 %	
MEDIUM		3	70 %	MEDIUM
LONG	2		18 %	
UNDESIRABLE			0 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
17	EARLIEST	1.1	73/75	74.1	1½ - 2½ YRS.
16	MOST LIKELY	1.1	76	75.9	3½ - 4½ YRS.
15	NOT LATER THAN	1.4	77/80	78.1	5½ - 7 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
15	LOWER LIMIT	.7	1 M	.84 M	.53 - 1.15
15	UPPER LIMIT	1.3	½ M	2.15 M	1.53 - 2.78

DOT ASSESSMENT RESULTS

EVENT: IXA04 A system as above IXA01, including a carbon dioxide removal system which utilizes a combined reaction method for both functions. The fully charged system weighs less than 30 pounds per 10 lbs of stored oxygen and occupies less than 1.5 cubic feet for each 10 lbs of stored oxygen. The system can be stopped and started as often as required. Routine maintenance is required on a 30-day basis and overhual interval is no less than one year

SYSTEM CRITICALITY

N= 17	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL			12 %	
DESIRABLE		6	82 %	DESIRABLE
UNNECESSARY	6		6 %	

DEGREE OF RISK

N= 17	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE	6		0 %	
.4 EXPERIMENTAL		7	82 %	.4
.7 SIMULATION			6 %	
.9 UNPROVEN	1		12 %	

DESIRED COURSE OF ACTION

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	11		20 %	
MEDIUM		8	27 %	
LONG		3	53 %	LONG
UNDESIRABLE			0 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
17	EARLIEST	1.4	74	74.6	2 - 3 YRS.
15	MOST LIKELY	1.5	75/77	76.4	3½ - 5 YRS.
15	NOT LATER THAN	1.8	78	79.2	6½ - 8 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
15	LOWER LIMIT	1.4	2 M	1.53 M	.86 - 2.20
15	UPPER LIMIT	3.6	3 M	3.60 M	2.01 - 5.27

DOT ASSESSMENT RESULTS

EVENT: IXA05 A carbon dioxide removal system for manned deep submergence vehicles using a chemical absorbent similar to lithium hydroxide (Li OH) for crews of 3 to 10 men for periods of 1 to 30 days. The system will remove 1.0 pounds of CO_2 for each pound of absorbent, for an atmosphere containing 0.7% CO_2. The system capacity requirement is 2.0 pounds per hour; noise level requirement is less than 50 db (above 0.0002 microbars); power consumption is less than 100 w; the mechanical hardware weighs less than 25lbs and occupies less than 3 cubic ft. The density of the absorbent material is greater than 20 pounds per cubic foot.

SYSTEM CRITICALITY

N- 18	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL		10	Δ	55 %	ESSENTIAL
DESIRABLE	5		Δ	28 %	
UNNECESSARY	5		Δ	17 %	

DEGREE OF RISK

N- 18	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE	1		Δ	28 %	
.4 EXPERIMENTAL		2	Δ	61 %	.4
.7 SIMULATION	1		Δ	11 %	
.9 UNPROVEN			Δ	0 %	

DESIRED COURSE OF ACTION

N- 18	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL		8	Δ	61 %	SHORT
MEDIUM	13		Δ	22 %	
LONG			Δ	0 %	
UNDESIRABLE		5	Δ	17 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
17	EARLIEST	o-o	.7	73	73.1	1 - 1½ YRS.
16	MOST LIKELY	o-o	.7	75	74.9	2½ - 3 YRS.
14	NOT LATER THAN	o-o	1.3	76	76.7	4 - 5½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
16	LOWER LIMIT	.3	.5 M	.36 M	.25 - .47
16	UPPER LIMIT	.7	1 M	1.10 M	.78 - 1.42

DOT ASSESSMENT RESULTS

EVENT: IXA06 A system as in IXA05, using the "LIMEA" system, as in nuclear submarines. The complete system weighs less than 400 pounds, occupies less than 20 cubic feet, and requires less than 2 kw for operation. When operating the noise level of the system is below 50 db. The system has a capacity of 2 pounds of CO_2 per hour from an atmosphere containing 0.7% CO2. A pump requirement is included for outboard disposal of CO_2 down to depths of 20,000 feet.

SYSTEM CRITICALITY

	PERCENTAGE		FINAL CONSENSUS %		
N= 16	LOSS	GAIN	0 25 50 75 100		CONCLUSION
ESSENTIAL	1		Δ	6 %	
DESIRABLE		2	Δ	81 %	DESIRABLE
UNNECESSARY	1		Δ	13 %	

DEGREE OF RISK

	PERCENTAGE		FINAL CONSENSUS %		
N= 15	LOSS	GAIN	0 25 50 75 100		CONCLUSION
.1 PROTOTYPE	2		Δ	19 %	
.4 EXPERIMENTAL		7	Δ	50 %	.4
.7 SIMULATION	4		Δ	25 %	
.9 UNPROVEN	1		Δ	6 %	

DESIRED COURSE OF ACTION

	PERCENTAGE		FINAL CONSENSUS %		
N= 15	LOSS	GAIN	0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL	7		Δ	7 %	
MEDIUM		9	Δ	59 %	MEDIUM
LONG		5	Δ	27 %	
UNDESIRABLE	7		Δ	7 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
16	EARLIEST	o-o	.8	75	74.2	2 - 2½ YRS.
15	MOST LIKELY	o-o	1.2	76/77	76.1	3½ - 4½ YRS.
13	NOT LATER THAN	o-o	1.6	80	78.3	5½ - 7 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
15	LOWER LIMIT	.7	.5/1M	.73 M	.42 - 1.05
15	UPPER LIMIT	1.4	1 M	1.91 M	1.27 - 2.54

DOT ASSESSMENT RESULTS

EVENT: IXA07 A system as in IXA05, using synthetic zeolites or "molecular sieves." The system has a maximum capacity of 2 pounds of CO_2 per hour from an atmosphere containing 0.7% CO_2, and when operating or recycling the noise level does not exceed 50 db. The system is completely self-contained, including equipment for recycling the zeolite; it weighs less then 400 pounds, occupies less than 40 cubic feet, and requires not more than 1 kw of power. The system includes a pump for outboard disposal of CO_2 down to depth of 20,000 feet.

SYSTEM CRITICALITY

N- 16	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL	7		Δ	6 %	
DESIRABLE		21	Δ	81 %	DESIRABLE
UNNECESSARY	14		Δ	13 %	

DEGREE OF RISK

N- 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE	7		Δ	0 %	
.4 EXPERIMENTAL		6	Δ	27 %	
.7 SIMULATION	3		Δ	40 %	.7
.9 UNPROVEN		4	Δ	33 %	

DESIRED COURSE OF ACTION

N- 16	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL		6	Δ	6 %	
MEDIUM	2		Δ	31 %	
LONG		3	Δ	57 %	LONG
UNDESIRABLE	7		Δ	6 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
16	EARLIEST	o-o	1.5	75	75.3	2½ - 4 YRS.
15	MOST LIKELY	o-o	1.7	78	77.7	5 - 6½ YRS.
13	NOT LATER THAN	o-o	2.1	80	80.2	7 - 9 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
15	LOWER LIMIT	.7	.5/1 M	.95M	.62 - 1.28
15	UPPER LIMIT	1.9	2 M	2.58M	1.69 - 3.47

DOT ASSESSMENT RESULTS

EVENT: IXA08 A system as in IXA07 using the "freeze-out" principle. The system is for use in conjunction with cryogenic oxygen supply systems and will use the vaporization of the oxygen to provide most of the refrigeration for the freeze-out process. The system weighs less than 300 pounds, occupies less than 30 cubic feet of space, and requires less than 1 kw of power for operation. The system has a minimum capacity of 2 pounds of CO_2 per hour from an atmosphere containing 0.7% CO_2. It includes a pump for outboard disposal of condensed CO_2 at depths to 20,000 feet. A refrigeration system for the required additional cooling capacity and the noise level of the system, when operating, is below 50 db.

SYSTEM CRITICALITY

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL	7		Δ	0 %	
DESIRABLE		0	Δ	27 %	
UNNECESSARY		7	Δ	73 %	UNNECESSARY

DEGREE OF RISK

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE			Δ	0 %	
.4 EXPERIMENTAL	13		Δ	7 %	
.7 SIMULATION	6		Δ	27 %	
.9 UNPROVEN		19	Δ	66 %	.9

DESIRED COURSE OF ACTION

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL	7		Δ	0 %	
MEDIUM	7		Δ	0 %	
LONG			Δ	40 %	
UNDESIRABLE		14	Δ	60 %	UNDESIRABLE

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
14	EARLIEST	o-o	1.0	75	75.3	3 - 4 YRS.
14	MOST LIKELY	o--o	1.7	76/78	77.8	5 - 6½ YRS.
12	NOT LATER THAN	o--o	2.7	80	80.5	7 - 10 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
13	LOWER LIMIT	.5	1 M	.97 M	.71 - 1.23
13	UPPER LIMIT	2.4	2 M	3.42M	2.23 - 4.60

DOT ASSESSMENT RESULTS

EVENT: IXA09 A system as in IXA05, including an oxygen regeneration system using an electrolytic/catalytic process. The system removes up to 3 pounds of CO_2 per hour from an atmosphere containing 0.7% CO_2 and by means of electric power converts the CO_2 into free oxygen and carbon powder. The unit is completely self-contained, weighs less than 400 pounds, occupies less than 40 cubic feet, and requires less than 2 kw. Its noise level, when operating, is less than 50 db. The solid carbon is stored onboard until the end of the mission.

SYSTEM CRITICALITY

N· 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	7		0 %	
DESIRABLE		7	27 %	
UNNECESSARY			73 %	UNNECESSARY

DEGREE OF RISK

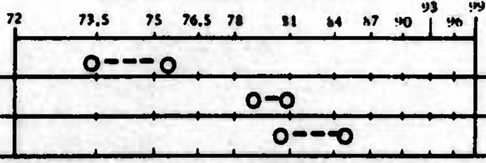
N· 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			0 %	
.4 EXPERIMENTAL			7 %	
.7 SIMULATION			60 %	.7
.9 UNPROVEN			33 %	

DESIRED COURSE OF ACTION

N· 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL			0 %	
MEDIUM			7 %	
LONG	16		27 %	
UNDESIRABLE		16	66 %	UNDESIRABLE

PROBABLE TIMING

CALENDAR YEARS
(90% CONFIDENCE INTERVAL)



N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
14	EARLIEST	2.0	75	76.4	3½ - 5½ YRS.
14	MOST LIKELY	2.6	78	79.5	6½ - 9 YRS.
12	NOT LATER THAN	3.7	80	82.8	9 - 12½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
14	LOWER LIMIT	1.1	2 M	1.74M	1.22 - 2.26
14	UPPER LIMIT	3.3	3/5 M	4.45M	2.87 - 6.03

DOT ASSESSMENT RESULTS

EVENT: DXA10 An emergency breathing system for use by personnel (in manned deep submergence vehicles). The system is a 100% oxygen closed circuit rebreather. It is made up of one-man carry-around units with full-face masks having internal oral-nasal fittings. Each unit is self-sufficient for 5 hours and can be connected directly to the ship's main oxygen supply if more time is required. The units weigh less than 8 pounds each and can be used as SCUBA gear for emergency escape in shallow water. The face masks are designed so that the face seal leakage is less than o.3 cubic feet per hour and the masks can be worn for periods up to 8 hours with reasonable comfort.

SYSTEM CRITICALITY

N= 17	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
ESSENTIAL	10		Δ	18 %	
DESIRABLE		10	Δ	82 %	DESIRABLE
UNNECESSARY			Δ	0 %	

DEGREE OF RISK

N= 17	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
.1 PROTOTYPE			Δ	18 %	
.4 EXPERIMENTAL	6		Δ	64 %	.4
.7 SIMULATION			Δ	12 %	
.9 UNPROVEN		6	Δ	6 %	

DESIRED COURSE OF ACTION

N= 17	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
SHORT RANGE GOAL		6	Δ	59 %	SHORT
MEDIUM	5		Δ	35 %	
LONG	1		Δ	6 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
17	EARLIEST	o-o	.8	74	73.9	1½ - 2½ YRS.
16	MOST LIKELY	o-o	.9	76	75.7	3½ - 4 YRS.
14	NOT LATER THAN	o--o	1.7	77	77.9	5 - 6½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
16	LOWER LIMIT	.3	.5 M	.38 M	.26 - .49
16	UPPER LIMIT	1.0	1 M	1.35 M	.90 - 1.81

DOT ASSESSMENT RESULTS

EVENT: IXA11 An electrically heated catalytic burner for the removal of carbon monoxide, hydrogen, and hydrocarbons from the atmosphere of a manned deep submergence vehicle, adequate for a crew of 3 to 10 men for periods of 1 to 30 days. The unit has an airflow of 50 CFM, a noise level below 50 db, and requires 0.5 kw for operation. The unit is less than 2 cubic feet in volume, weighs 30 pounds, and requires routine maintenance on a weekly basis.

SYSTEM CRITICALITY

N· 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL		7		60 %	ESSENTIAL
DESIRABLE				40 %	
UNNECESSARY	7			0 %	

DEGREE OF RISK

N·	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE		14		67 %	.1
.4 EXPERIMENTAL				20 %	
.7 SIMULATION	7			13 %	
.9 UNPROVEN	7			0 %	

DESIRED COURSE OF ACTION

N· 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL		13		60 %	SHORT
MEDIUM	14			33 %	
LONG		1		7 %	
UNDESIRABLE				0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
15	EARLIEST		.7	74	73.9	1½ - 2 YRS.
14	MOST LIKELY		.8	75	75.4	3 - 3½ YRS.
12	NOT LATER THAN		1.2	78	77.3	4½ - 6 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
14	LOWER LIMIT	.5	.5 M	.52 M	.29 - .75
14	UPPER LIMIT	.5	1.5 M	1.35 M	.90 - 1.80

DOT ASSESSMENT RESULTS

EVENT: IXA12 A unit as previously described except that it includes a particle filter and a carbon odor control canister. The unit volume is 3 cubic feet and it weighs 40 pounds.

SYSTEM CRITICALITY

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL		6	Δ	33 %	
DESIRABLE			Δ	60 %	DESIRABLE
UNNECESSARY	6		Δ	7 %	

DEGREE OF RISK

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE		13	Δ	46 %	.1
.4 EXPERIMENTAL		7	Δ	27 %	
.7 SIMULATION	13		Δ	27 %	
.9 UNPROVEN	7			0 %	

DESIRED COURSE OF ACTION

N= 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL		9	Δ	36 %	
MEDIUM	10		Δ	50 %	MEDIUM
LONG		1	Δ	14 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
15	EARLIEST	o-o	.6	74	74.0	1½ - 2½ YRS.
14	MOST LIKELY	oo	.9	76	75.6	3 - 4 YRS.
12	NOT LATER THAN	o-o	1.4	78	77.7	5 - 6½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
14	LOWER LIMIT	.5	.1/1M	.62 M	.37 - .87
14	UPPER LIMIT	1.0	2 M	1.49 M	1.02 - 1.96

DOT ASSESSMENT RESULTS

EVENT: IXA13 A temperature and humidity control system for use on manned deep submergence vehicles having crews of 3 to 10 men for missions of 1 to 30 days duration. The system will maintain the temperature in the personnel spaces at 75 ± 5°F, and the relative himidity at 65 ± 10% RH. The system operates on the thermoelectric principle and rejects heat directly through the pressure hull wall. The system occupies 8 cubic feet, weighs 150 pounds, and requires 1,000 w of power for 3 men and 10,000 BTU heat rejection capability.

SYSTEM CRITICALITY

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
ESSENTIAL			Δ	60 %	ESSENTIAL
DESIRABLE			Δ	40 %	
UNNECESSARY			Δ	0 %	

DEGREE OF RISK

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
.1 PROTOTYPE	7		Δ	7 %	
.4 EXPERIMENTAL	2		Δ	27 %	
.7 SIMULATION		9	Δ	66 %	.7
.9 UNPROVEN			Δ	0 %	

DESIRED COURSE OF ACTION

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % 0 25 50 75 100		CONCLUSION
SHORT RANGE GOAL	5		Δ	60 %	SHORT
MEDIUM		6	Δ	20 %	
LONG	1		Δ	20 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
14	EARLIEST	o--o	[illegible]	74	74.6	2 - 3½ YRS.
13	MOST LIKELY	o-o	1.6	76	76.5	3½ - 5½ YRS.
12	NOT LATER THAN	o--o	1.9	78	78.3	5½ - 7½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
14	LOWER LIMIT	1.6	.2 M	1.43M	.69 - 2.18
14	UPPER LIMIT	3.9	1/5 M	3.96M	2.09 - 5.84

DOT ASSESSMENT RESULTS

EVENT: IXA14 A system as in IXA13 but operating on the vapor compression system, using a non-toxic fluid.

SYSTEM CRITICALITY

N= 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 – 25 – 50 – 75 – 100)		CONCLUSION
ESSENTIAL		12	Δ	43 %	ESSENTIAL
DESIRABLE	3		Δ	43 %	
UNNECESSARY	9		Δ	14 %	

DEGREE OF RISK

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 – 25 – 50 – 75 – 100)		CONCLUSION
.1 PROTOTYPE	1		Δ	7 %	
.4 EXPERIMENTAL		3	Δ	80 %	.4
.7 SIMULATION	2		Δ	13 %	
.9 UNPROVEN			Δ	0 %	

DESIRED COURSE OF ACTION

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 – 25 – 50 – 75 – 100)		CONCLUSION
SHORT RANGE GOAL		3	Δ	53 %	SHORT
MEDIUM			Δ	33 %	
LONG	10		Δ	7 %	
UNDESIRABLE		7	Δ	7 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
15	EARLIEST	o-o	1.3	74	74.1	1½ - 2½ YRS.
14	MOST LIKELY	o-o	.9	76	75.6	3 - 4 YRS.
13	NOT LATER THAN	o-o	1.3	78	77.8	5 - 6½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
14	LOWER LIMIT	.6	.5 M	.64 M	.36 - .93
14	UPPER LIMIT	1.0	3 M	1.79 M	1.31 - 2.28

DOT ASSESSMENT RESULTS

EVENT: IXA15 A cloth material suitable for making coveralls and other garments, bedding, cushion covers, etc., which has the feel of cotton, is comfortable, order free, mildew resistant and fireproof in atmospheres with oxygen concentrations up to 40%

SYSTEM CRITICALITY

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL	19		Δ	27 %	
DESIRABLE		19	Δ	73 %	DESIRABLE
UNNECESSARY			Δ	0 %	

DEGREE OF RISK

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE	15		Δ	27 %	
.4 EXPERIMENTAL		18	Δ	60 %	.4
.7 SIMULATION		5	Δ	13 %	
.9 UNPROVEN	8		Δ	0 %	

DESIRED COURSE OF ACTION

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL	8		Δ	67 %	SHORT
MEDIUM		8	Δ	33 %	
LONG			Δ	0 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
15	EARLIEST	o--o	1.5	74	73.9	1½ - 2½ YRS.
14	MOST LIKELY	o--o	1.8	75	75.6	2½ - 4½ YRS
13	NOT LATER THAN	o---o	2.5	76	77.4	4 - 6½ YRS

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
13	LOWER LIMIT	.3	.5 M	.38M	.25 - .50
13	UPPER LIMIT	.4	1 M	1.06M	.86 - 1.26

DOT ASSESSMENT RESULTS

EVENT: IXA16 A resilient padding material suitable for stuffing cushions and mattresses which is comfortable to recline on, permeable to moisture, non-hygroscopic, mildew resistant, odorless, and fireproof in atmospheres with oxygen concentrations up to 40%.

SYSTEM CRITICALITY

N= 15	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
ESSENTIAL	7		Δ	20 %	
DESIRABLE		7	Δ	80 %	DESIRABLE
UNNECESSARY			Δ	0 %	

DEGREE OF RISK

N= 13	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
.1 PROTOTYPE	18		Δ	0 %	
.4 EXPERIMENTAL		27	Δ	54 %	.4
.7 SIMULATION		1	Δ	38 %	
.9 UNPROVEN	10		Δ	8 %	

DESIRED COURSE OF ACTION

N= 14	PERCENTAGE		FINAL CONSENSUS %		CONCLUSION
	LOSS	GAIN	0 25 50 75 100		
SHORT RANGE GOAL	5		Δ	57 %	SHORT
MEDIUM		13	Δ	43 %	
LONG	8		Δ	0 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
14	EARLIEST	o-o	.8	74	73.9	1½ - 2 YRS.
12	MOST LIKELY	oo	.6	76	75.5	3 - 4 YRS.
11	NOT LATER THAN	o-o	1.7	78	78.1	5 - 7 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
11	LOWER LIMIT	.3	.5 M	.38 M	.24 - .53
11	UPPER LIMIT	.6	1 M	1.28 M	.93 - 1.64

DOT ASSESSMENT RESULTS

EVENT: IXA17 A fire extinguishing system suitable for type A and type C fires which is either automatic or manually controlled with discharge nozzles that can be strategically located to reach critical locations. The extinguishing medium is electrically non-conductive, non-toxic, and does not evolve any toxic material or large quantities of irritating vapors or dust when in contact with surface temperatures up to 1,000°F. The system is effective in oxygen concentrations up to 40% and after use the residue is readily removable.

SYSTEM CRITICALITY

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
ESSENTIAL		10	Δ	53 %	ESSENTIAL
DESIRABLE	10		Δ	47 %	
UNNECESSARY			Δ	0 %	

DEGREE OF RISK

N= 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
.1 PROTOTYPE		5	Δ	14 %	
.4 EXPERIMENTAL		12	Δ	58 %	.4
.7 SIMULATION	11		Δ	7 %	
.9 UNPROVEN	6		Δ	21 %	

DESIRED COURSE OF ACTION

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS % (0 25 50 75 100)		CONCLUSION
SHORT RANGE GOAL		10	Δ	60 %	SHORT
MEDIUM	17		Δ	33 %	
LONG		7	Δ	7 %	
UNDESIRABLE			Δ	0 %	

PROBABLE TIMING

N		CALENDAR YEARS (90% CONFIDENCE INTERVAL) 72 73.5 75 76.5 78 81 84 87 90 93 96 99	σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
15	EARLIEST	o o	.9	74	74.5	2 - 3 YRS.
13	MOST LIKELY	o-o	1.8	75	76.5	3½ - 5½ YRS.
12	NOT LATER THAN	o--o	2.4	78	78.4	5 - 7½ YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLIONS) (90% CONFIDENCE INTERVAL)
13	LOWER LIMIT	.8	.5 M	.86 M	.48 - 1.24
13	UPPER LIMIT	2.4	2 M	2.18 M	.99 - 3.38

DOT ASSESSMENT RESULTS

EVENT: IXA18 A waste containment and control system for manned deep submergence vehicles which will hold and sterilize garbage, waste water, and urine and fecal material in a device which traps all odors. The basic system weighs 10 pounds, and it requires 1.5 cubic feet for each 6-man day of storage capacity. The system seals each day's waste into a separate plastic container and sterilizes it to prevent the development of gas, ordors, and bacteria. The bags can be either retained until the vehicle surfaces or disposed at depth.

SYSTEM CRITICALITY

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
ESSENTIAL	6		47 %	
DESIRABLE		6	53 %	DESIRABLE
UNNECESSARY			0 %	

DEGREE OF RISK

N= 14	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
.1 PROTOTYPE			7 %	
.4 EXPERIMENTAL			64 %	.4
.7 SIMULATION			0 %	
.9 UNPROVEN			29 %	

DESIRED COURSE OF ACTION

N= 15	PERCENTAGE LOSS	PERCENTAGE GAIN	FINAL CONSENSUS %	CONCLUSION
SHORT RANGE GOAL	3		33 %	
MEDIUM		4	54 %	MEDIUM
LONG	1		13 %	
UNDESIRABLE			0 %	

PROBABLE TIMING

CALENDAR YEARS (90% CONFIDENCE INTERVAL)

N		σ	MODE(S)	MEAN	DEVELOPMENT TIME (FROM 1972)
15	EARLIEST	1.3	74	74.5	2 - 3 YRS.
13	MOST LIKELY	1.5	76	76.2	3½ - 5 YRS.
12	NOT LATER THAN	1.9	78	78.1	5 - 7 YRS.

ESTIMATED COSTS TO ACHIEVE

N		σ	MODE(S)	MEAN	DEVELOPMENT COSTS (IN MILLONS) (90% CONFIDENCE INTERVAL)
14	LOWER LIMIT	.8	.8 M	.89M	.53 - 1.26
14	UPPER LIMIT	1.6	1/2 M	1.96M	1.21 - 2.72

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)*

U. S. Navy Department
Naval Material Command, MAT - 034
Washington, D.C. 20360

2a. REPORT SECURITY CLASSIFICATION

UNCLASSIFIED

2b. GROUP

N/A

3. REPORT TITLE

DEEP OCEAN TECHNOLOGY PROJECT DEVELOPMENT OBJECTIVE ASSESSMENT

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

Final

5. AUTHOR(S) *(First name, middle initial, last name)*

William J. Greenert and Benjamin F. Witt

6. REPORT DATE

27 October 1973

7a. TOTAL NO. OF PAGES

335

7b. NO. OF REFS

0

8a. CONTRACT OR GRANT NO.

[redacted]

b. PROJECT NO.

S46-36X

c.

WBS 13000

d.

9a. ORIGINATOR'S REPORT NUMBER(S)

0341-
MAT ~~034~~/73

9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*

N/A

10. DISTRIBUTION STATEMENT

Each transmittal of this document outside the agencies of the U.S. Government must have prior approval of Naval Material Command, MAT 0341.

11. SUPPLEMENTARY NOTES

Technology Assessment

12. SPONSORING MILITARY ACTIVITY

Naval Material Command
Washington, D.C. 20360

13. ABSTRACT

This document is an assessment of specific technological events, anticipated and/or desired in the near future, required to advance the state-of-the-art in ocean engineering for the achievement of Naval objectives.

In conducting the study a modified DELFHI technique was used to obtain evaluations from a selected sample of 240 specialists from industry and government currently involved in the following ocean engineering disciplines.

- Materials and Structures
- Machinery and Equipment
- Seafloor Construction
- Power Sources, Conversion & Transmission
- Propulsion
- Surveillance and Communication
- Instrumentation and Display
- Load Handling and Transportation
- Life Support and Related Systems

The specific events within the above areas were evaluated relative to the following criteria:

- System Criticality
- Degree of Risk
- Desired Course of Action
- Probable Timing
- Estimated Costs to Achieve

DD FORM 1 NOV 65 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

UNCLASSIFIED

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Technology Assessment						
Deep Submergence						
Ocean Engineering						
DELPHI Forecast						
Undersea Materials & Structures						
Undersea Machines and Equipments						
Undersea Constructions						
Undersea Power						
Undersea Surveillance & Communication						
Undersea Instrumentation						
Undersea Load Handling						
Undersea Life Support						
Undersea Propulsion						