UNCLASSIFIED

AD NUMBER

AD480384

NEW LIMITATION CHANGE

TO

Approved for public release, distribution unlimited

FROM

Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; Mar 1966. Other requests shall be referred to Marine Engineering Lab [Navy], Annapolis, MD 21402.

AUTHORITY

USNSSC ltr, 17 Sep 1969

THIS PAGE IS UNCLASSIFIED

UNITED STATES NAVY
MARINE ENGINEERING LABORATORY
ANNAPOLIS, MARYLAND—21402
AREA CODE 301 268-7711

IN REPLY REFER TO:

NP/9820(628 KHK)
Assigt. 62 701
Rept. 110/66
12 APR 1966

From: Commanding Officer and Director
To: Director, Special Projects Office

Subj: MEL Research and Development Phase Report 110/66; Transmittal of

1. Transmitted herewith is MEL Research and Development Report 110/66, Reliability Prediction for a Deep Submergence Rescue Vehicle; Second Reliability Model, Assignment 62 701.

R. J. Wylde

R. J. WYLDE
By direction

Copy to:
(See Distribution List, Page ii)

BEST

AVAILABLE

COPY

Reliability Prediction for a
Deep Submergence Rescue Vehicle;
Second Reliability Model;

Assignment 62 701
MEL R&D Phase Report 110/66
March 1966

By

Robert L. Ragot and
Robert L. Hamilton

ROBERT L. RAGOT

ROBERT L. HAMILTON

Approved by:

R. J. WYLDE
Electrical Systems Division

ABSTRACT

A second reliability model of the Deep Submergence Rescue Vehicle (DSRV) is defined. On the basis of this model, a prediction is made of the DSRV reliability for a typical rescue mission. The predicted reliability is computed to be 29%, for a 26-hour vehicle-operating time. The major factor contributing to the low predicted reliability of the vehicle is the high failure rate assumed for the forward and skirt (exterior) lamps. A two-orders-of-magnitude decrease in the assumed failure rate for these underwater lamps results in a predicted reliability of about 80%. Recommendations are made for improving future DSRV reliability studies.

MEL Report 110/66

ADMINISTRATIVE INFORMATION

The effort reported herein was funded under Special Projects Fund Category PC 6-0005. MEL Assignment number was 62-701.

REFERENCES

(a) MEL Reliability Memorandum No. 4, of 14 July 1965, DSRV First-Cut Reliability Analysis; Mission Definition and Scope of the Analysis

(b) ARINC Research Corp. Report of 1 June 1965, Initial DSRV Rescue Mission Reliability Analysis

(c) ARINC Research Corp. Report of 30 June 1965, Deep Submergence Rescue Vehicle Equipments Reliability Predictions and Allocations

(d) SPO Proposal Request SP001-0139-66, of 28 September 1965, Circular of Requirements for Design and Construction of Deep Submergence Rescue Vehicle

(e) NASL Dwg LP-9500-23 TM-2 of 30 June 1965 (As revised), Sensor Placement (External) Rescue Vehicle

(f) NASL Lab. Project 9500-23 TM-2 of June 1965, Sensor Suit for the Prototype Deep Submergence Rescue Vehicle

(g) MEL Dwg. No. SK00001 of 28 August 1965, Single-Thread Drawing Numbering System

RELIABILITY PREDICTION FOR A DEEP SUBMERGENCE RESCUE VEHICLE, SECOND RELIABILITY MODEL

1.0 INTRODUCTION

This report explains the need for a second reliability model for the Deep Submergence Rescue Vehicle (DSRV), defines the second model, and presents the results of the computer run made with it. It is emphasized that although the second model is considered an improvement over the first model, it in turn has its limitations. Rather than discontinue the reliability prediction effort because an exact representation of the vehicle cannot be achieved, it will be continued as long as there are significant improvements to be made in the reliability prediction.

1.1 Background. The DSRV is currently being developed by the Special Projects Office (SPO) as a means of rescuing personnel from a distressed submarine on the ocean bottom. Under the Task Statement of SPO Project Order No. 5-0009 (Budget Project 20), of 23 April 1965, the U. S. Navy Marine Engineering Laboratory (MEL), Annapolis was requested to conduct studies leading to the prediction of reliability for the entire rescue vehicle (including all electrical/electronic and mechanical subsystems, and structures of the vehicle).

The desired completion date for the initial study was June 30, 1965. Due to a shortage of both available time and personnel, MEL secured contractor support to perform a major part of the initial study. The following study tasks, however, were performed by MEL:

- System definition: based on a U. S. Navy Bureau of Ships (BUSHIPS) concept drawing and equipment lists from Sensors and Navigation and Integrated Control and Display Subsystem managers.

- Definition of mission (rescue trip): phases and phase times for that portion of a rescue mission when the DSRV operates alone (outlined in Appendix A). These times were correlated with the Technical Development Plan (TDP) generated by SPO. The number of rescue trips required to rescue the distressed submarine's personnel complement was determined by correspondence with BUSHIPS Code 525 (Submarines Branch).

● Definition of the total elapsed mission time: 36½ hours, and total vehicle operating time of 26.2 hours.

● Assignment of use-factors (by means indicated in reference (a)) to each of the vehicle components for each phase of the mission.

Study tasks performed by the contractor were:

● Construction of the first system model (block diagram) and development of reliability equations for the system.

● Development of a computer program to calculate reliabilities for the components, vehicle functions, and the entire vehicle.

● Determination of best available, and most appropriate, failure rate data for DSRV components.

Results of the initial reliability study are reported in references (b) and (c). These references contain the system block diagrams, the computed reliabilities and a basic failure-rate data package. This data package contains many composite failure rates which are supported by a more detailed data package retained by MEL. The computer program (in the form of card decks) was supplied to MEL as part of the contractor's study task, and is on file for record purposes.

2.0 SUMMARY

2.1 The second reliability model for the DSRV incorporates more accurate system structuring plus corrections to several component failure rates. A vehicle reliability of 29% for a 36½-hour rescue mission has been computed for the second model. This is much lower than the 88% (predicted) and 94% (allocated) figures which resulted from the first model. The most significant contribution to this low reliability of 29% is made by the high failure rate assumed for the forward and skirt (exterior) lamps.

2.2 An approximate tradeoff of vehicle reliability versus the failure rate for these lamps (see Figure 1) indicates a reduction in the assumed failure rate (from 166,000 to 1,660 failures per million operating hours) will increase the predicted vehicle reliability to about 80%. No significant increase

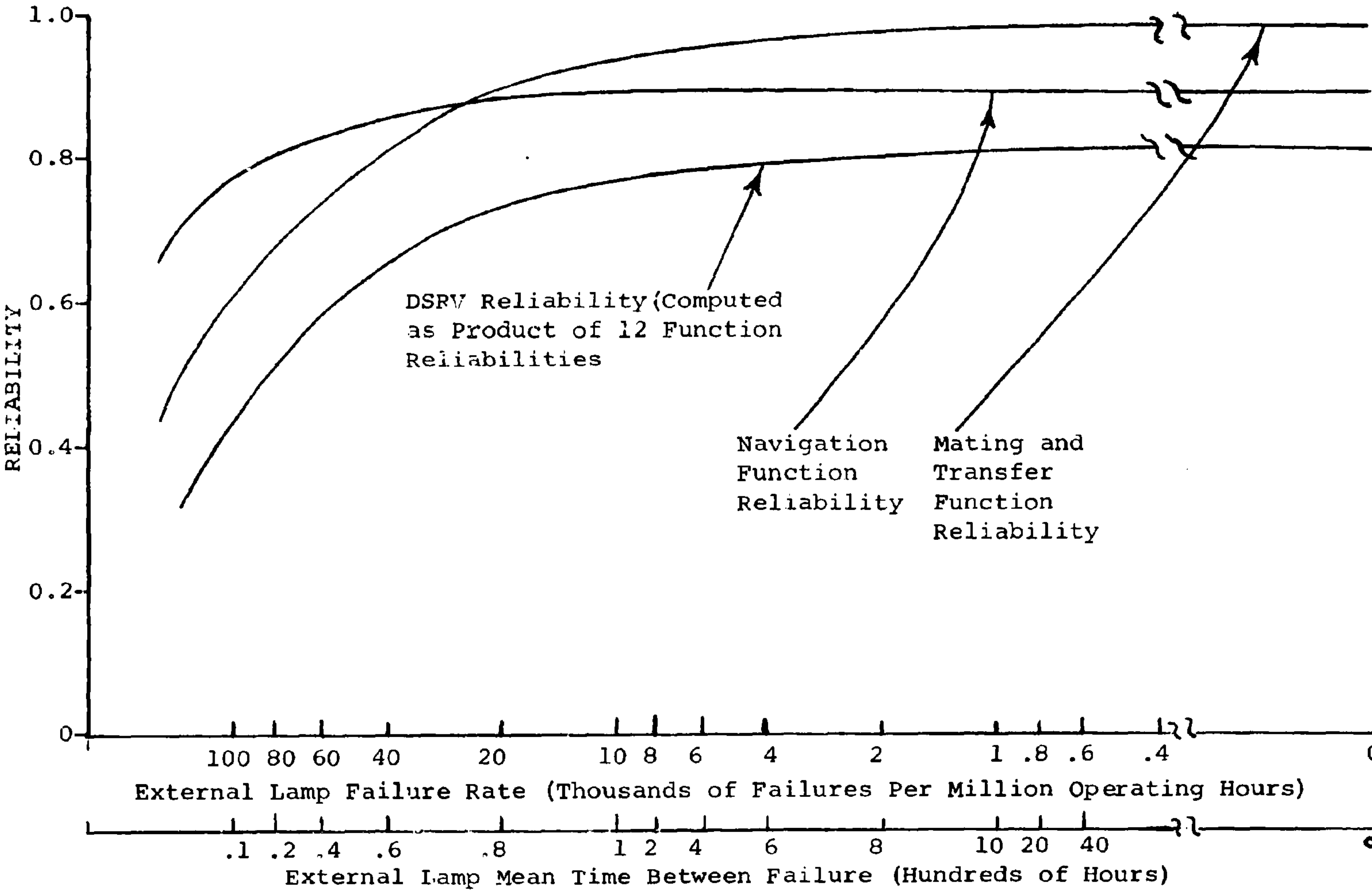


Figure 1 - Tradeoffs (Approximate) of Lamp Failure Rate Versus DSRV Reliability

beyond 80% is realized for further reduction in the lamp failure rate.

2.3 Further improvement in DSRV reliability beyond the 80% value can be effected by:

- Generally decreasing other component failure rates.

- Including system DSRV, or functional redundancies which were not known during the development of the second model.

- Adding redundant equipment.

2.4 Recommendations are made for improving future DSRV reliability studies. These recommendations include:

- Performance of additional detailed studies including operational sequence analysis and sensitivity studies.

- Construction of a reliability model which allows for dependency of component failures.

- Determination of component failure distributions, and summing to yield composite failure-time distributions for subsystems and/or capabilities of the vehicle.

- An output data format which highlights changes and deficiencies. Deficiencies could then be immediately identified with a weak component, subsystem, or equipment of the vehicle - performance weaknesses could also be highlighted.

3.0 NEED FOR NEW MODEL

A new DSRV model is required because the definition of the original model for the DSRV was a simplified expedient to meet a contract deadline. It was admittedly not a good representation of the DSRV as it existed prior to June 1965 and, subsequent to the publication of references (b) and (c), there have been changes in the DSRV concept. Several components have had new failure rates ascribed to them.

Examples of the inadequacies of the first model together with the changes in concept and the changed failure rates are presented in the following paragraphs.

3.1 Inadequacies. In reference (c), Figures 2 and 13 (which are block diagrams of the Navigation function) indicate the vertical obstacle avoidance sonar as an alternate to the short range sonar, televisions and viewports. This is an error. It is a long-range, forward-looking device used to detect obstacles, while the short-range sonar is a downward-looking sonar, used to get a close-range sonar "picture" of the distressed submarine's hatch area. While the televisions and viewports may be forward-looking, they are again short-range.

Figure 13 of reference (c) shows the horizontal obstacle avoidance sonar as an alternate to the short-range sonar, televisions and viewports. Again, this is a misconception.

3.2 Changes in Concept. As stated in reference (d), there will be only two emergency breathing equipments on the DSRV, one for the two operators and one for the medical corpsman. Previously there were to have been three for the DSRV crew, plus fifteen (including three spares) for the rescuees.

The control and rescue sphere hatches will not be required to keep out sea pressure. However, these hatches will be required to seal against a maximum external pressure of five atmospheres (see reference (d)). This is the highest pressure personnel could tolerate (for any appreciable time) inside the distressed submarine.

The first model considered two forward-pointing and six downward-pointing 650-watt lamps plus a single 250-watt skirt lamp. The latest sensor placement drawing (reference (e)) by the Naval Applied Science Laboratory (NAVAPLSCIENLAB) shows the following (exterior) lamps:

- Two 800-watt, forward-pointing lamps.

- Five 250-watt, downward-pointing lamps (one, located forward, is trainable fore, aft and down).

- A single 85-watt skirt lamp.

3.3 Changes in Failure Rates. According to NAVAPLSCIENLAB the underwater telephone will have a lower failure rate than is assigned in the first model, due to the use of transistorized components. The new failure rate is 222 failures per million operating hours. (This corresponds to a mean time between failure of 4,500 hours.)

New failure rates have been assigned to the new lamps mentioned above in paragraph 3.2 on the basis of mean, or rated, life figures supplied by NAVAPLSCIENLAB. With no other information available, the assumption is made that these mean-life figures are equivalent to mean time between failures. The (assumed) failure rates (the reciprocals of mean time between failure) are:

(a)	800-watt lamps	16,600 Failures per million operating hours
(b)	250 and 85-watt lamps	166,000 Failures per million operating hours

4.0 DEFINITION OF SECOND MODEL

Definition of the second DSRV model includes the block diagrams, reliability equations, assumptions and limitations and input data which are used to compute vehicle reliability.

4.1 Block Diagrams. Figures 1 through 12 of Appendix B are block diagrams representing the twelve functions which comprise the DSRV. The second model is based on the same basic DSRV concept as the first model. A comparison with Figures 1 through 12 of reference (c), however, shows some significant differences in the logical connections of the two models. These differences are due not to the changes in concept, but to a different and, it is hoped, a more accurate interpretation of the DSRV concept. The degree of accuracy of the second model remains to be determined.

4.2 Reliability Equations. Appendix C contains the FORTRAN statement* used for computing DSRV reliability in the second model. The reliability equations for the twelve figures of Appendix B are listed as sequences (SEQ) 11 through 22. Overall DSRV reliability is computed as the product of these twelve equations. Sequences (SEQ) 34 through 45 are the reliability

* For details of the computer program set up for the second model, see MEL Technical Memorandum 415/66 of December 1965, Deep Submergence Rescue Vessel Reliability Prediction.

equations for the same twelve functions, when considered separately.

4.3 Assumptions and Limitations. Inherent in the definition of the second model are the following considerations:

- Clear water exists at the rescue site. This enables the use of optical aids, as well as the use of short-range sonar in the mating operation.

- Beacons suitable for aiding DSRV navigation are planted prior to the first rescue trip.

- There are active personnel aboard the distressed submarine. This enables DSRV homing on hull noise (hammering).

- A single television camera will be sufficient for manipulator operation.

- Only the three television cameras described in Appendix A of reference (f) are considered. This constitutes a limitation of the model since there are presently four television cameras on the DSRV (See reference (d)).

- The rescue mission is as defined in reference (a), and as abbreviated in Appendix A of this report.

- The viewport optical reliability (probability of no optical degradation) is assumed equal to the viewport structural reliability.

- Emergency breathing equipment reliability is assumed equal to that of the oxygen storage, control and display equipment.

- The helium storage, control and display equipment included in the Life Support function will probably not be in the DSRV. Inclusion of this equipment makes the Life Support function model somewhat conservative.

- DSRV components have an exponential failure distribution.

- DSRV component failures are independent (failure of one does not cause failure of another).

Other components not included in the model are the portable radiation detector, differential pressure gauge, the inverters for the sonars and other Sensor/Navigation equipments, the sonar (mechanical) installation, film cameras, strobe lights, recorder and telemetry and ultra high-frequency radio. The radio, cameras, strobe lights and recording equipment are not critical in completing the mission, and are therefore not included. Omission of the other components constitues a limitation of the model. Maintenance of the vehicle is not considered.

4.4 Input Data. Component operating times and failure rates complete the definition of the second model. Appendix D includes a computer listing of all input data in numerical order following the component drawing numbers established in reference (g). Appendix E is a computer listing of the data, in numerical order of assigned* component numbers.

Several changes in component failure rates have been made to correct errors made in transposing them from the data package, which was a working document, to the Reliability Data report, which is part of reference (c). These changes are listed, by assigned number, in Appendix F.

In several instances, changes in component operating times were made to be consistent with the second model or with new battery and hydraulic package power-profiles. These power profiles were changed to agree with operating time estimates of NAVAPLSCIENLAB and Howard Research Corporation. These changes in operating time are listed in Appendix F.

5.0 RESULTS

Appendix D contains the print-out of the computer results for the second model. Pages 1 through 6 present the equipment and component reliabilities. Page 7 lists the twelve function reliabilities and the overall DSRV reliability figure of 29%. In computing these function reliabilities, each component is considered in only one of the twelve functions, during any given time period. This disregards the fact that, operationally, the component could be contributing to more than one function at a time. Since so many components contribute

* Each component is given an identification (or assigned) number, for use in the computer program.

to both the Navigation and the Search and Surveillance functions during the same time period (i.e., the functions overlap in time and in shared components), all components of these systems were considered under Navigation alone. The Search and Surveillance function was then assigned a reliability of unity. This procedures does not affect the overall vehicle reliability, but does make it impossible to separate these two functions.

A list appears on page 8 of Appendix D of the twelve function reliabilities with the functions considered separately. In computing these "functional" reliabilities, all components which operationally affect a function are included. Thus, some components may contribute to several different functions. These functional reliabilities are, therefore, sometimes smaller than the function reliabilities listed on page 7 of Appendix D.

6.0 DISCUSSION OF RESULTS

The study based on the first model (reference (c)) computed a predicted vehicle reliability of 88%, and on the basis of a few changes in the prediction model and the addition of a redundant component (an underwater telephone), an allocated reliability of 94%. Generally, a somewhat lower value than 88% or 94% would be expected for the second model, simply because the structure (block diagram) of the second model is more conservative than the first model. By conservative it is meant the second model considers as series-connected components, several components which were considered as parallel-connected components in the first model. The predicted reliability of 29% for the second model is much lower than was expected.

Table 1 of this report is a comparison of the function reliabilities of the second model with those of the first model. From the values presented for the second model, it is clear that the cause of the low vehicle reliability lies with the Navigation* function (reliability of 66%) and the Mating and Transfer Function (reliability of 46%) - either in the structuring of these two functions or in the component reliabilities used in them.

* Note that this is the combined Navigation-Search and Surveillance function mentioned in paragraph 5.0.

TABLE I

A COMPARISON OF THE FUNCTION RELIABILITIES FOR THE FIRST AND SECOND DSRV RELIABILITY MODELS

Function	First Model Prediction	First Model Allocation	Second Model Prediction
1. Vehicle Control and Propulsion	0.9933	0.9933	0.9884
2. Navigation	0.9434	0.9434	0.6632
3. Structural Integrity	0.9993	0.9993	0.9966
4. Communication	0.9876	0.9968	0.9934
5. Manipulator	0.9896	0.9896	0.9994
6. Mating and Transfer	0.9966	0.9966	0.4646
7. Surveillance and Search	0.9991	0.9991	1.0000*
8. Computer	0.9987	0.9987	0.9988
9. Life Support	0.9911	0.9911	0.9911
10. Power and Distribution	0.9824	0.9824	0.9824
11. Hydraulic Package	0.9976	0.9976	0.9983
12. External Sensors	0.9974	0.9974	0.9999
Vehicle Reliability (Product of twelve function reliabilities)	0.8838	0.9431	0.2925

* In the second model, the Surveillance and Search function is accounted for in the Navigation function.

Examining the component reliabilities in Appendix D reveals that the (exterior) lamps are the only components having lower reliabilities than 92%; most components having reliabilities greater than 99%. At the bottom of Figure 2 (Navigation), of Appendix B, the trainable lamp (123)* is shown to be in parallel with two fore lamps (112). Inserting the corresponding reliabilities in the reliability equation for this combination of components gives roughly 66%. These lamps, then, are the cause of the low reliability computed for the Navigation function.

A similar examination of Figure 6 (Mating and Transfer) of Appendix B indicates that the skirt lamp (146), with a reliability of about 48%, is the primary cause of the low reliability (46%) for the Mating and Transfer function.

Figure 1 of this report presents the (approximate) tradeoffs of lamp failure rate versus the resulting Vehicle, Navigation and Mating and Transfer function reliabilities. No significant increase in vehicle reliability beyond about 80% results from decreasing the failure rate of the lamps more than two orders of magnitude below the value ascribed to them in the second reliability model. For the same decrease in lamp failure rate, the reliability of the Navigation and Mating and Transfer functions will approach maximums of 88% and 96% respectively.

From the above discussion, it is evident that although the low lamp reliabilities are the direct cause of the low reliability in the second model, either (a) the structuring of the Navigation and the Mating and Transfer functions or (b) the component reliabilities (other than the lamp reliabilities) used in these functions become the limiting factors of vehicle reliability, when high lamp reliability is assumed. The determination of the structuring details, or component reliabilities which limit the vehicle reliability in the second model to a maximum of about 80% is not within the scope of this study.

* Numbers in parentheses are assigned numbers for components (See Appendices D & E).

7.0 CONCLUSIONS

On the basis of the DSRV model defined herein, the following conclusions are made:

- The exterior lamps (the skirt and forward lamps specifically) are the most significant contributors to DSRV unreliability. This is due primarily to their high (assumed) failure rates.

- Even with very reliable skirt and forward lamps, the DSRV reliability approaches a maximum of only about 80%.

- Skirt and forward lamp reliability (and the reliability of the other external lamps as well) needs to be improved. A reduction in the skirt and forward lamp failure rate of between one and two orders of magnitude would be worthwhile, in terms of increased vehicle reliability (increasing it from 29% to about 80%).

- Further study is required to improve the Navigation and the Mating and Transfer function reliabilities (exclusive of lamps). This is mandatory if any significant increase in DSRV reliability beyond about 80% is to be attained. Improvement could be made by

  - decreasing component failure rates

  - restructuring the functional models to include redundant paths which may have been missed in the second model, or

  - adding redundant equipment.

8.0 RECOMMENDATIONS AND FUTURE PLANS

Improvements in the present method used to predict DSRV reliability and in the utilization of the information available from DSRV reliability studies are considered necessary. It is, therefore, recommended that all future DSRV reliability studies include the items listed below. Future MEL efforts in reliability prediction will use these improvements to the greatest extent possible within funding and time limitations.

8.1 An operational analysis which emphasizes operations involving the DSRV and its mother vessel only. This analysis will establish better use-factors for the individual components and for the vehicle systems. It is felt that the use-factors can be more readily estimated for vehicle capabilities than for any other defined element in the structural model of the system. The reasoning behind this conclusion is that capabilities can be related to both the mission event-time sequence and to contributing hardware. (See Appendix G for the location of capabilities in the structural model).

8.2 Establishment of procedures for the determination and reporting of failure distributions (versus time) for all vehicle components, subsystems, capabilities and functions.

8.3 A dependency analysis to account for the effect of failure of one component on the operation of another. In combination with this analysis, the construction of a logic-oriented reliability model wherein no vehicle component appears more than once (at any given time) in the total vehicle reliability equation. Examples of such a model (block diagrams) are shown in Appendix G.

8.4 Additional sensitivity analyses, similar to the one which resulted in Figure 1, to determine the sensitivity of all functions, capabilities, and composite failure distributions and parameter values.

8.5 Maintainability and safety analyses which would contribute to tradeoff studies with reliability. Skirt lamps, for example, could be replaced during each light-on (DSRV on mother ship) period. Other lamps cannot be replaced without sacrificing a great deal of mission time.

8.6 An output data format similar to that used in this report, i.e., one which shows computed reliabilities for vehicle components, sub-systems, capabilities, and major vehicle functions. Changes in component failure distribution and other input data, and the addition or deletion of components, should be highlighted under appropriate headlines. With such a format, deficiencies (low reliabilities) in these areas can be readily identified with deficient hardware items, and corrective action initiated. For example, the reliability runoff might indicate that the "look down" capability has a low reliability during the mating phase of the rescue mission, and pin point the primary cause to be the low reliability of a particular component. A possible remedy to this problem would be to restrict the use of this particular component to only the mating phase, thus reducing the total component operating time and thereby improving the component reliability.

Appendix A

Mission Phases and Phase Times

MISSION PHASES	PHASE TIME (MINUTES)			
	TRIP 1	TRIP 2	TRIP 3 THRU N-1	TRIP N
1. UNCOUPLE FROM MOTHER SUBMARINE	5	5	5	5
2. DESCENT	13	13	13	13
3. SURVEILLANCE AND APPROACH	20	20	7	7
4. ANCHOR AND ALIGNMENT	7	7	7	7
5. HATCH PREPARATION AND MARKER	13	3	3	3
6. WINCH HOOK AND HAUL DOWN	5	5	5	5
7. SKIRT DEWATERING	5	5	5	5
8. PRESSURE EQUALIZATION	3	3	3	3
9. TRANSFER OF RESCUEES	25	25	25	25
10. UNCOUPLE FROM DISTRESSED SUB.	5	5	5	5
11. ASCENT	13	13	13	13
12. SURVEILLANCE AND APPROACH	7	7	7	7
13. ANCHOR AND ALIGNMENT	7	7	7	7
14. WINCH HOOK AND HAUL DOWN	5	5	5	5
15. SKIRT DEWATERING	5	5	5	5
16. PRESSURE EQUALIZATION	3	3	3	3
SUB TOTALS	141	131	118	118
17. TRANSFER OF RESCUEES AND RECHARGE BATTERIES	50	50	50	25
TOTALS	191	181	168	143

Appendix B

Second DSRV Model Block Diagrams

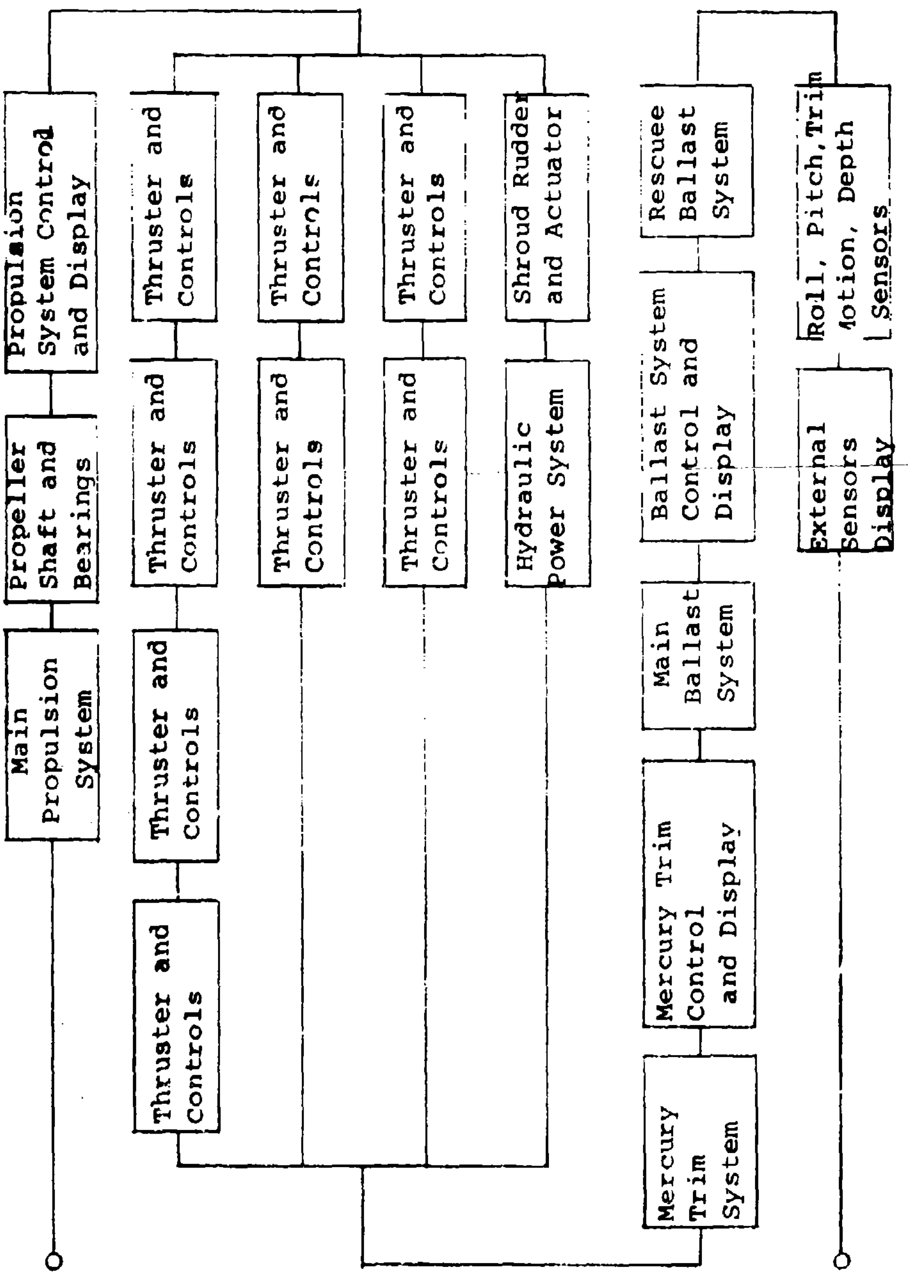


FIGURE 1
VEHICLE CONTROL AND PROPULSION

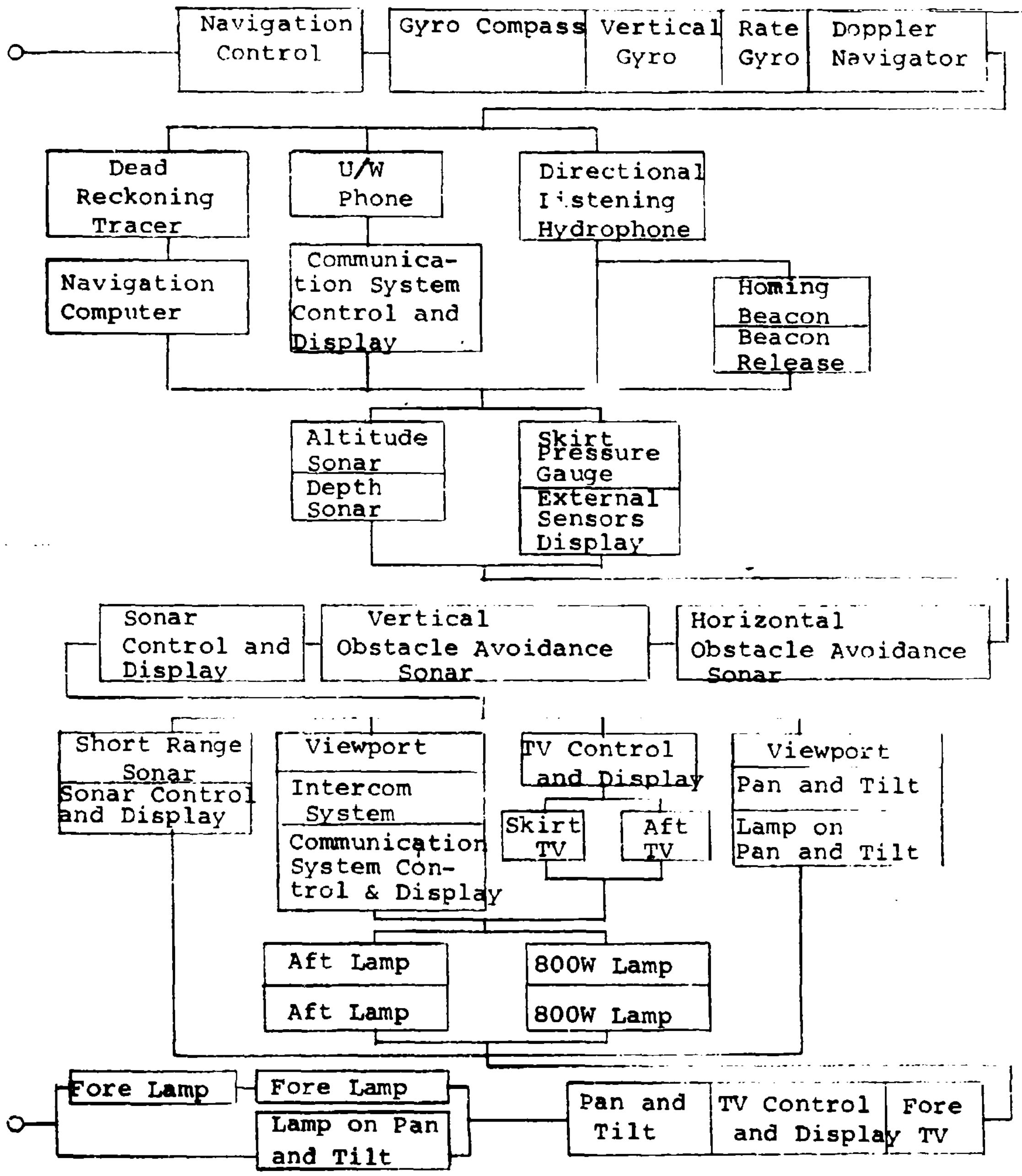


FIGURE 2

NAVIGATION

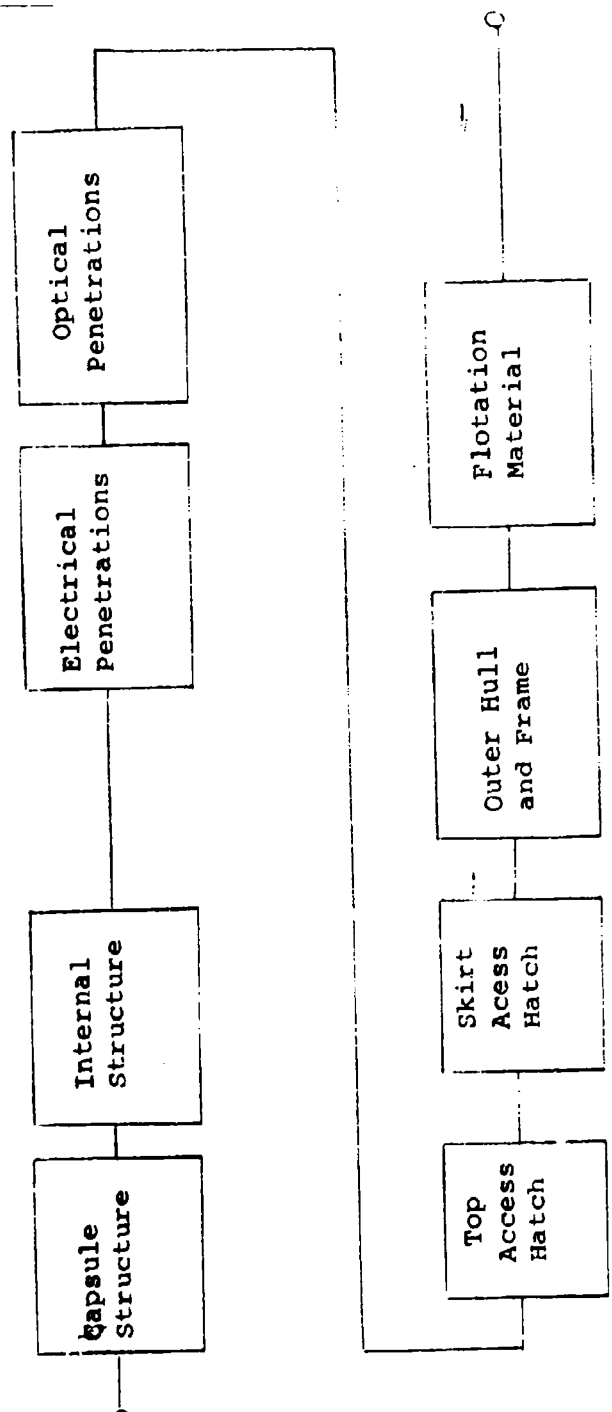


Figure 3
Structures

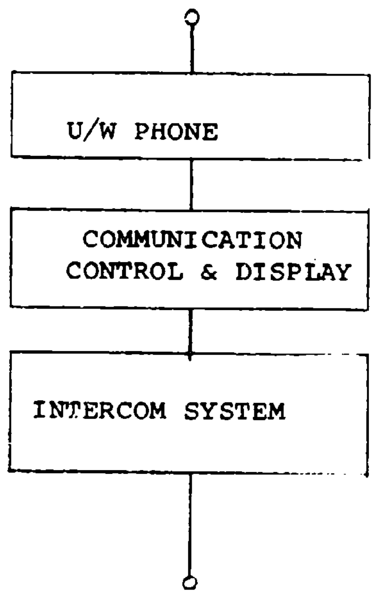


FIGURE 4

COMMUNICATION

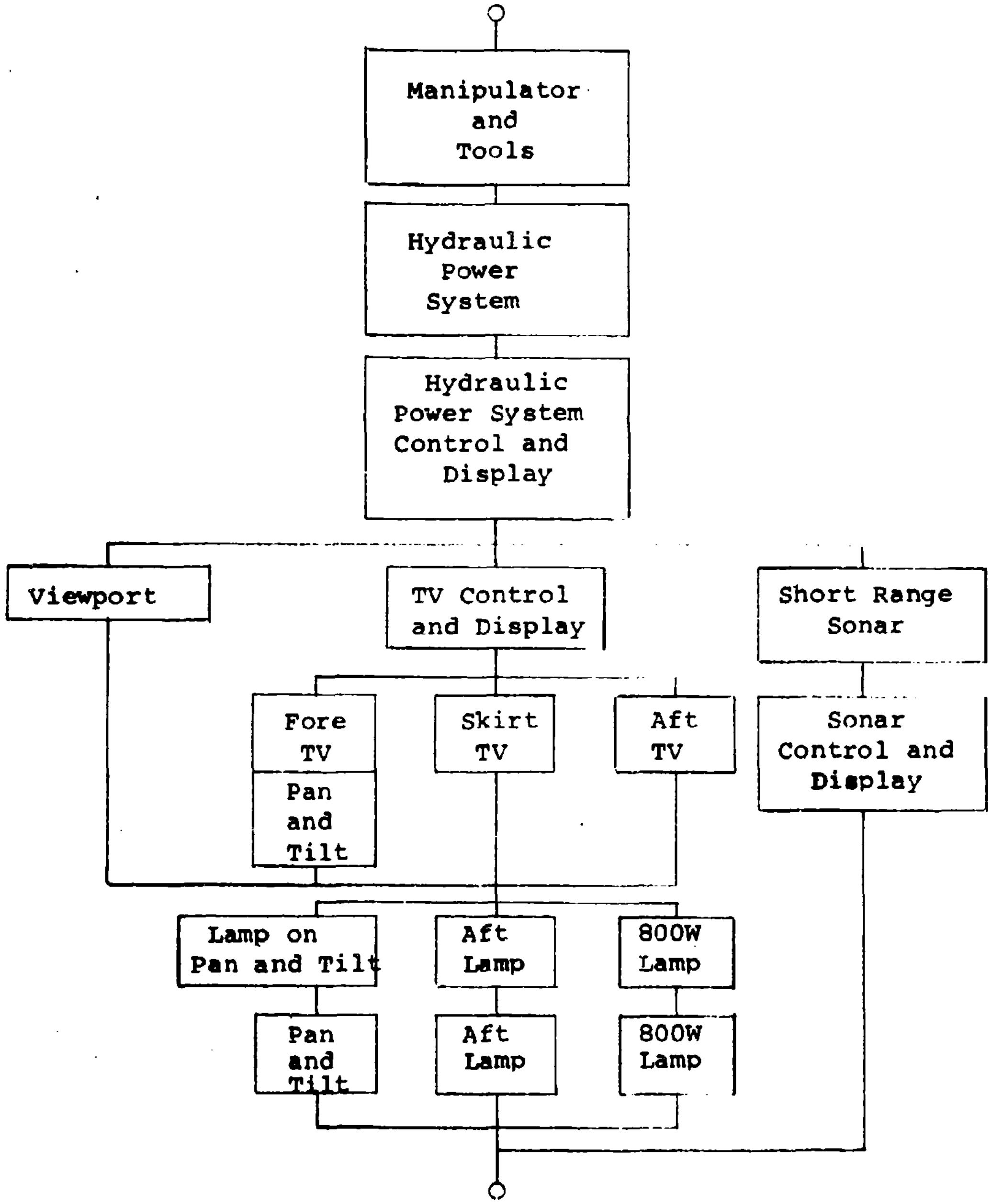


FIGURE 5

MANIPULATOR

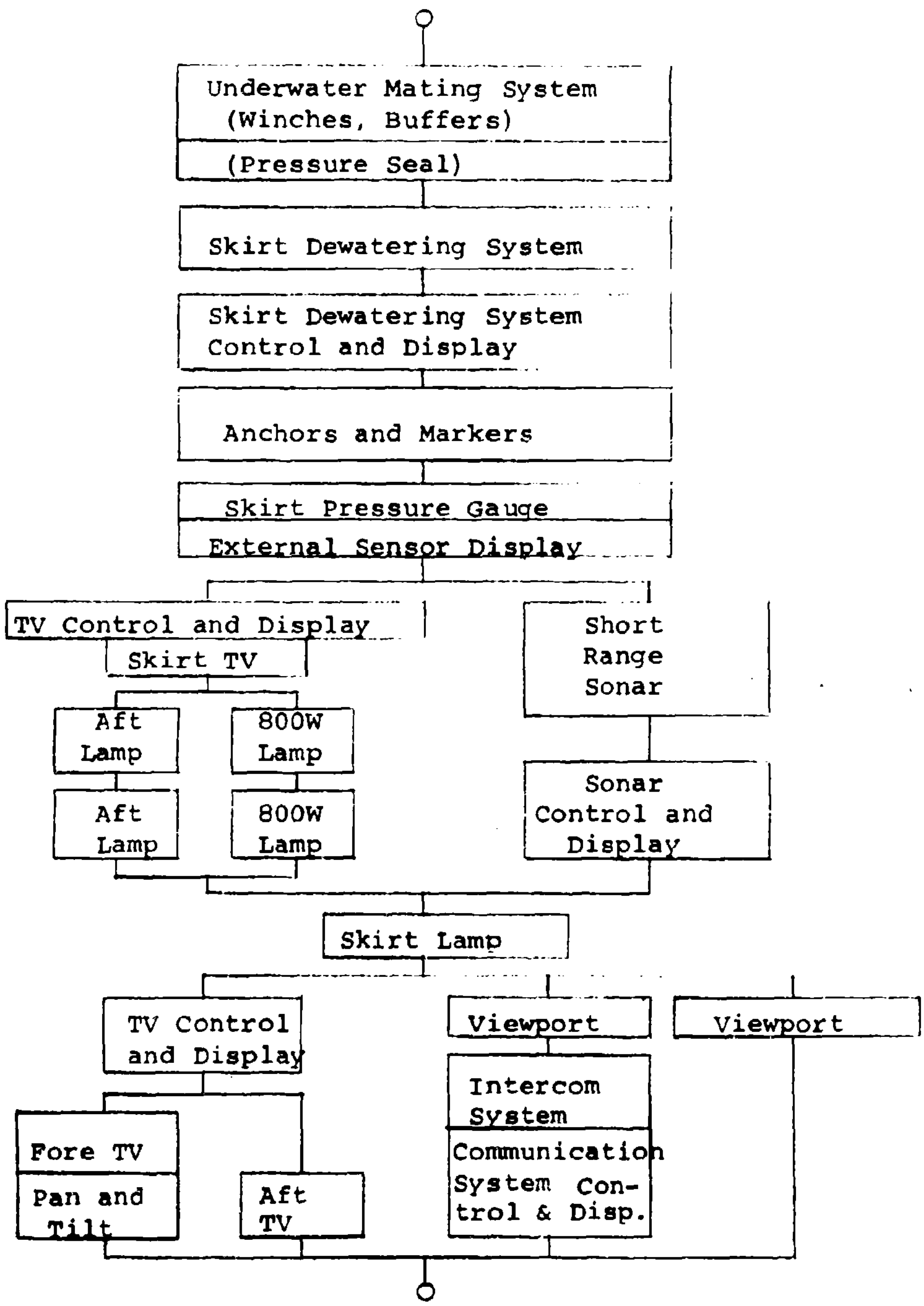


FIGURE 6

MATING AND TRANSFER

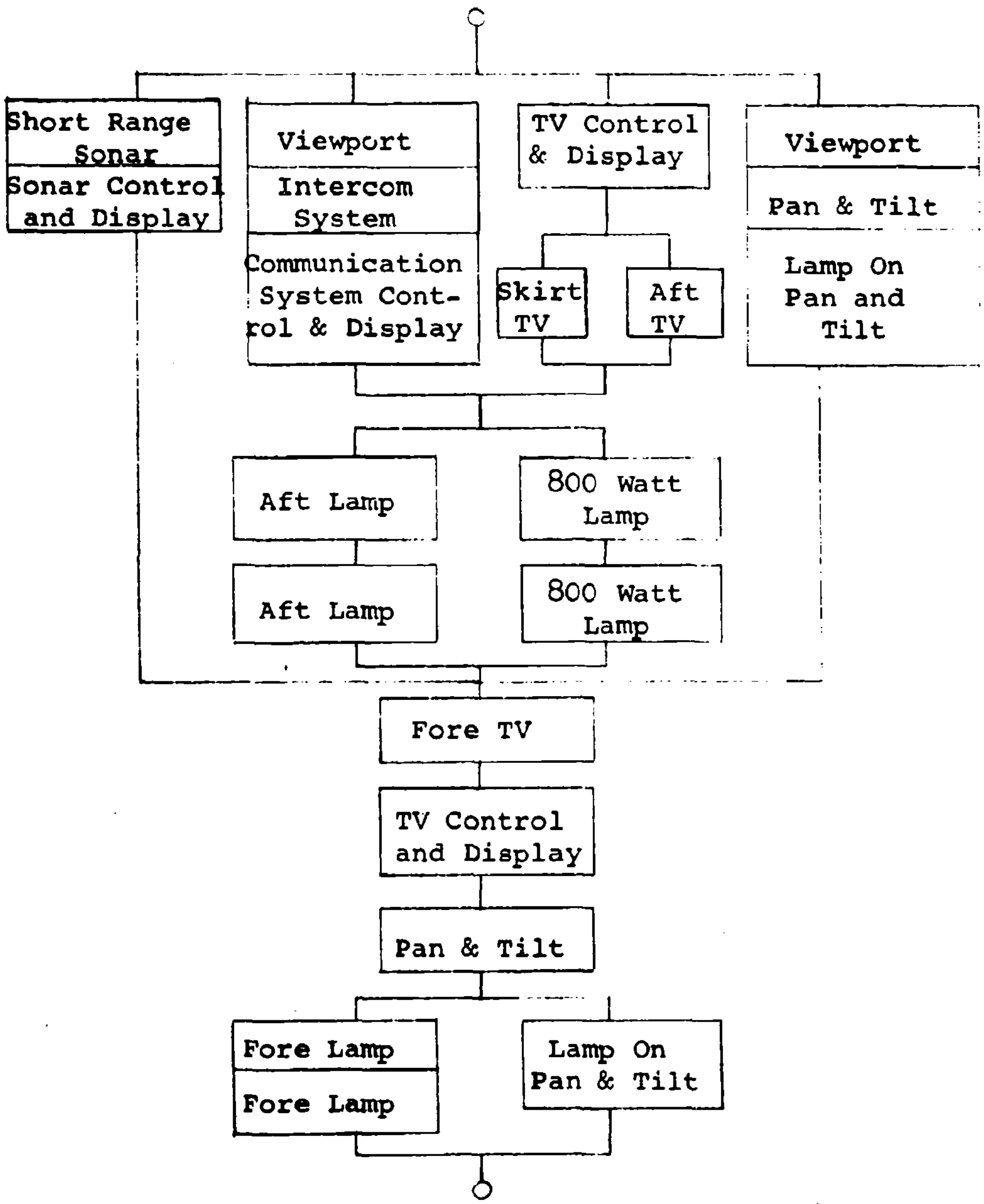


FIGURE 7

SEARCH AND SURVEILLANCE

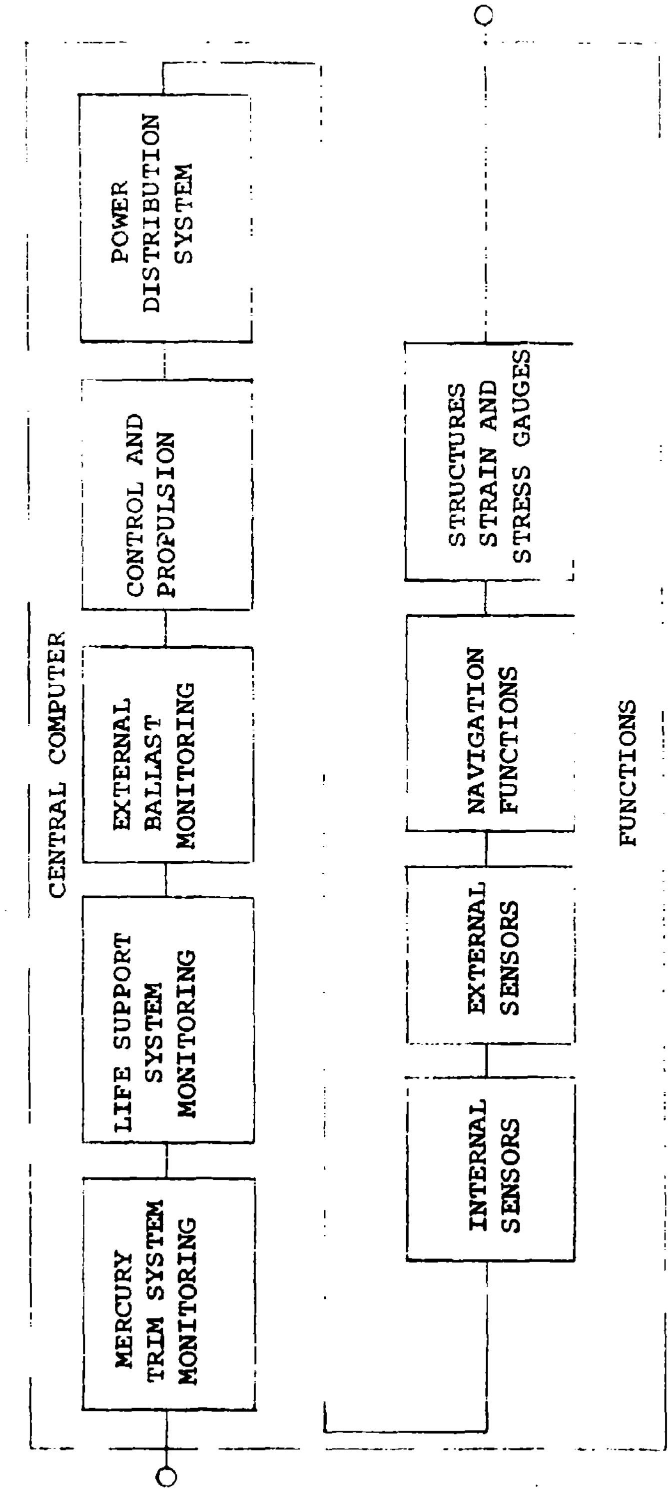


FIGURE 8

COMPUTER

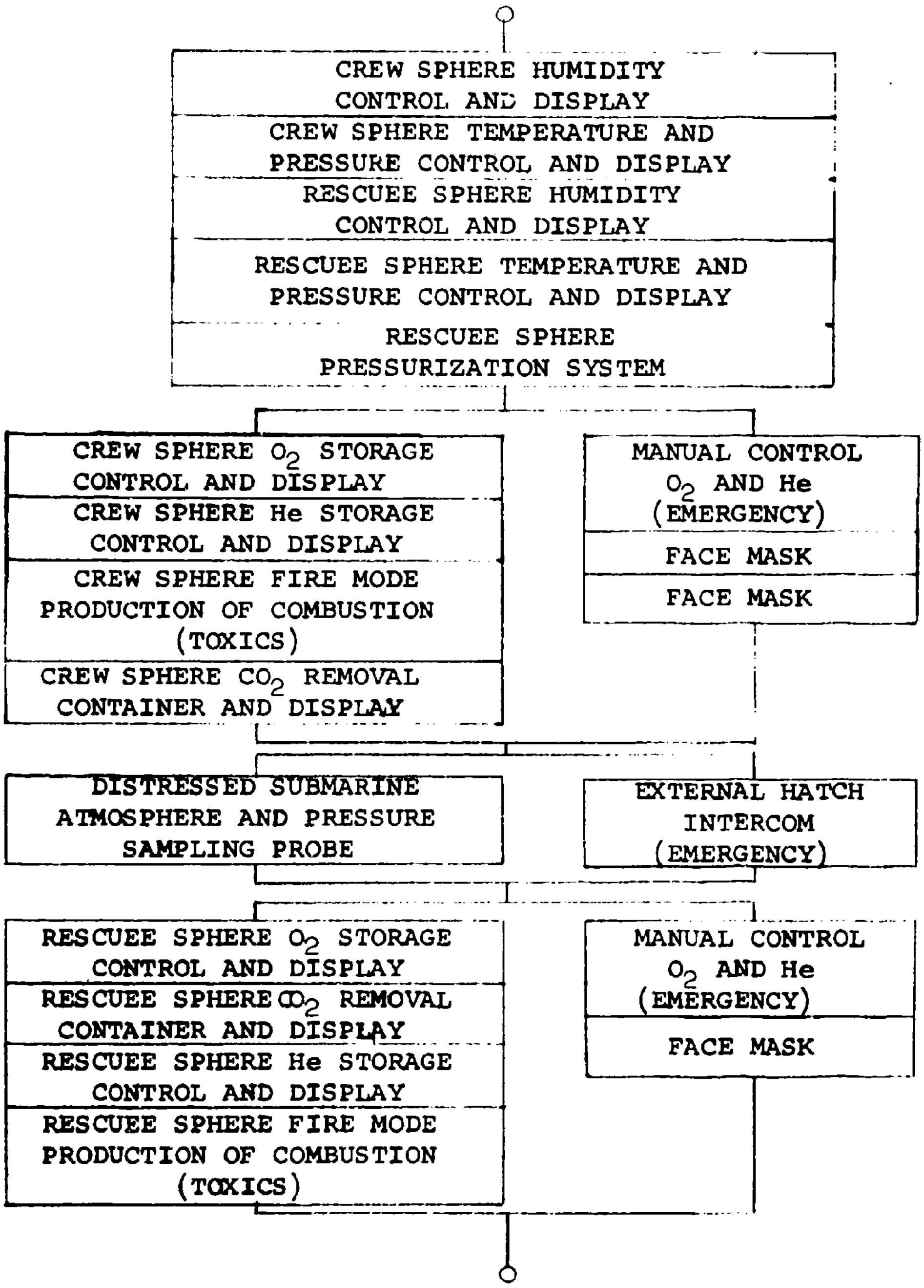


FIGURE 9

LIFE SUPPORT

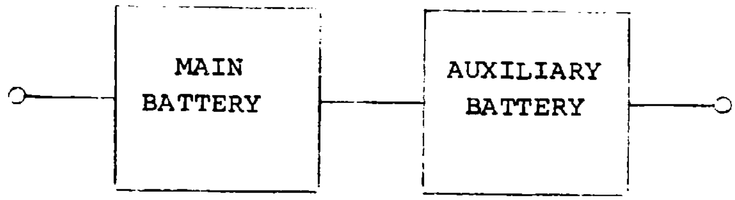


FIGURE 10

POWER AND DISTRIBUTION

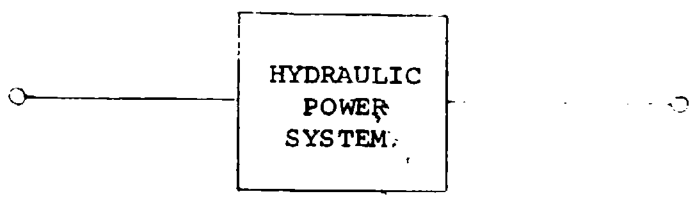


FIGURE 11

HYDRAULIC POWER SYSTEM

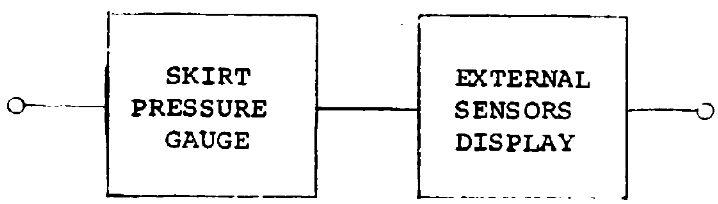


FIGURE 12

EXTERNAL SENSORS

Appendix C

Second DSRV Model Fortran Computer Statement

```
STMNT    FORTRAN STATEMENT

C
C        PROGRAM TO COMPUTE RELIABILITY OF DSRV FOR A 13 TRIP MISSION
C        MODIFIED SEPT. 1,1965
C                THIS IS WORST CASE. I.E.,NO REPAIRS ALLOWED AND
C                ALTERNATE MODES ARE ACTIVE.
C
         DIMENSION R(250),DSNO(3),FREL(12),FUNCN (12,2),FRELP (12)
         READ 500,(FUNCN(I,1),FUNCN(I,2),I=1,12)
    1    PRINT 100
         L=0
    2    L=L+1
         IF(L-24)3,3,1
    3    READ 200,F,DSNO,T1,T2,T3,T4,TSUM,FR,NAS
         R(NAS)=EXPF(-FR*TSUM)
         PRINT 300,F,DSNO,T1,T2,T3,T4,TSUM,FR,NAS,R(NAS)
         IF(SENSE SWITCH 0)22,2
   22    FREL (1) R(7)*R(8)*R(12)*R(14)*R(10)*R(195)*R(11)*R(16)*R(17)*R(18
        1)*(1.-(((1.-R(13)**4)*(1.-(1.-(1.-R(13)**2)*(1.-R(13)**2)))*(1.-R(9
        2)*R(110))))
         FREL (2)= R(28)*R(30)*R(32)*R(22)*R(19)*R(180)*R(181)*(1.-(1.-R(20
        1)*R(24))*(1.-R(113)*R(126))*(1.-R(114))*(1.-R(114)*R(27)*R(23)))*(
        21.-(1.-R(142)*R(143))*(1.-R(115)*R(161)))*(1.-(1.-R(116)*R(197))*(
        31.-R(120)*R(184)*R(123))*(1.-(1.-(1.-R(120)*R(119)*R(182))*(1.-R(1
        483)*(1.-(1.-R(117))*(1.-R(118))))))*(1.-(1.-R(121)**2)*(1.-R(122)**
        52))))*R(111)*R(183)*R(184)*(1.-(1.-R(112)**2)*(1.-R(123)))
        X*R(196)
         FREL(3)=R(33)*R(124)*R(35)**2*R(36)*R(37)*R(38)*R(39)
         FREL(4)= R(125)*R(127)*R(128)
         FREL (5)= R(44)*R(129)*(1.-(1.-R(130)*R(198))*(1.-(R(185)*R(186)*
        1R(187))*(1.-(1.-R(188))*(1.-R(134)**2)*(1.-R(135)**2)))*(1.-(1.-(1
        2.-R(131))*(1.-(1.-R(186)*(1.-(1.-R(132))*(1.-R(133))))))*(1.-(1.-
        3R(188)*R(187))*(1.-R(134)**2)*(1.-R(135)**2))))
         FREL (6)=R(136)*R(137)*R(1  )*R(139)*R(140)*R(141)*R(162)*R(146)*
        1(1.-(1.-R(144)*R(199))*(1.- R(145)*R(201))*(1.-(1.-R(147)**2)*(1.-
        2R(148)**2))))*(1.-(1.-R(150))*(1.-R(150)*R(15))*R(174))*(1.-(R(190
        3))*(1.-(1.-R(189)*R(191))*(1.-R(149))))))
         FREL (7) = 1.
         FREL (8) =R(58)*R(59)*R(60)*R(61)*R(62)*R(64)*R(63)*R(65)
         FREL (9)=R(71)*R(73)*R(78)*R(80)*R(82)*(1.-(1.-R(69)*R(72)*R(74)*R
        1(70))*(1.-R(76)*R(69)**2))*(1.-(1.-R(76)*R(77)*R(79)*R(81))*(1.-R(
        269)*R(76)))
        X*(1.-(1.-R(202))*(1.-R(203)) )
         FREL (10)=R(85)*R(84)
         FREL (11)=R(160)
         FREL (12)=R(163)*R(164)
         PROD=1.
         DO 4 I=1,12
    4    PROD=PROD*FREL(I)
         PRINT 600,(FUNCN(I,1),FUNCN(I,2),FREL(I),I=1,12)
         PRINT 700,PROD
  100    FORMAT(1H1,20X,71HLISTING OF COMPONENTS AND FAILURE RATES USED IN
        1 RELIABILITY COMPUTATION ///10X,109H FUNCTION  DESCRIPTION  DRAWING
        2   OPERATING TIMES MINUTES  TOT. OPER.  FAILURE RATE  ASSIGNED NO.
        3  RELIABILITY /20X,53HOF  COMP.       NO.     T1    T2 T3-12  T13
        4     HRS. )
```

```
STMNT      FORTRAN STATEMENT

  300      FORMAT(13X,A1,4X,2A8,A8,4F5.0,8X,F5.2,6X,F9.8,8X,I3,11X,F7.6//)
  200      FORMAT(A1,2A8,A8,4F4.0,F7.2,9XF8.7,I3)
  500      FORMAT(10A8)
  600      FORMAT (1H1, (22H    RELIABILITY FOR   2A8,3H ISF9.6//))
  700      FORMAT(1H0//50HORELIABILITY OF D.S.R.V. FOR 13 TRIP MISSION IS
        1  F9.6)
   42      FRELP (1)= FREL (1)
           FRELP (2)= FREL (2)
           FRELP (3)=FREL (3)
           FRELP (4)=R(170)*R(127)*R(128)
           FRELP (5)= FREL (5)
           FRELP (6)= FREL (6)
           FRELP (7)=(1.-(1.-R(152)*R(200))*(1.-R(177)*R(159)*R(192))*(1.-(1.
        1  -(1.-R(177)*R(155)*R(158))*(1.-R(193))*(1.-(1.-R(153))*(1.-R(154)
        2  ))))*(1.-(1.-R(175)**2)*(1.-R(176)**2))))*R(156)*R(193)*R(192)*(1.
        3  -(1.-R(157)**2)*(1.-R(194)))
           FRELP (8)=R(58)*R(59)*R(60)*R(61)*R(62)*R(64)*R(63)*R(24)*R(65)
           FRELP (9)=FREL (9)
           FRELP(10)=FREL (10)
           FRELP (11)= R (171)
           FRELP (12)=R(172)*R(173)
           PRINT 800,(FUNCN (I,1),FUNCN (I,2),FRELP (I),I=1,12)
  800      FORMAT(1H1,(32H    FUNCTIONAL RELIABILITY FOR  2A8,3H IS F9.6//))
           END
```

Appendix D

Second DSRV Model Computer Print-out

LISTING OF COMPONENTS AND FAILURE RATES USED IN RELIABILITY COMPUTATION

FUNCTION	DESCRIPTION OF COMP.	DRAWING NO.	OPERATING TIMES MINUTES T1	T2	T3-12	T13	TOT. OPER. HRS.	FAILURE RATE	ASSIGNED NO.	RELIABILITY
N	U/W PHONE	03-0101-01	55.	55.	42.	42.	9.50	0.00022200	113	0.997893
C	U/W PHONE	03-0101-01	81.	71.	71.	71.	15.50	0.00022200	125	0.996565
C	U/W PHONE	03-0101-01	141.	131.	118.	118.	26.10	0.00022200	170	0.994223
L	HATCH PH + 1C	03-0101-02	3.	3.	3.	3.	0.65	0.00004000	203	0.999974
S	HATCH PH + 1C	03-0101-02	14.	14.	14.	14.	3.00	0.00004000	155	0.999880
N	HATCH PH + 1C	03-0101-02	14.	14.	14.	14.	3.00	0.00004000	119	0.999880
M	HATCH PH + 1C	03-0101-02	10.	10.	10.	10.	2.20	0.00004000	151	0.999912
C	HATCH PH + 1C	03-0101-02	141.	131.	118.	118.	26.10	0.00004000	128	0.998957
N	DOPP NAV	03-0108-01	49.	49.	36.	36.	8.30	0.00200000	19	0.983537
N	DEAD RECK TRC	03-0108-02	55.	55.	42.	42.	9.50	0.00010000	20	0.999050
N	RATE GYRO PKG	03-0108-04	191.	181.	168.	142.	36.50	0.00006000	22	0.997812
N	NAV DISP	03-0108-07	55.	55.	42.	42.	9.50	0.00001080	28	0.999897
V	MTN + DPTH SE	03-0108-14	100.	90.	77.	77.	17.20	0.00029300	14	0.994973
N	FORE TV CAM	03-0123-01	14.	14.	14.	14.	3.00	0.00333300	111	0.990051
S	FORE TV CAM	03-0123-[illegible]	27.	27.	14.	14.	3.50	0.00333300	156	0.988402
P	FORE TV CAM	03-0123-01	[illegible]	8.	8.	8.	1.90	0.00333300	185	0.993687
M	FORE TV CAM	03-0123-0[illegible]	10.	10.	10.	10.	2.20	[illegible]	189	0.992694
M	SKIRT TV CAM	03-0123-02	20.	20.	20.	20.	4.40	0.000[illegible]00	145	0.[illegible]921
P	SKIRT TV CAM	03-0123-02	18.	8.	8.	8.	1.90	0.00001800	132	0.999966
S	SKIRT TV CAM	03-0123-02	14.	14.	14.	14.	3.00	0.00001800	153	0.999946
N	SKIRT TV CAM	03-0123-02	14.	14.	14.	14.	3.00	0.00001800	117	0.999946
N	AFT TV CAM	03-0123-03	14.	14.	14.	14.	3.00	0.00333300	118	0.990051
P	AFT TV CAM	03-0123-03	18.	8.	8.	8.	1.90	0.00333300	133	0.993687
M	AFT TV CAM	03-0123-03	20.	20.	20.	20.	4.40	0.00333300	149	0.985442

LISTING OF COMPONENTS AND FAILURE RATES USED IN RELIABILITY COMPUTATION

FUNCTION	DESCRIPTION OF COMP.	DRAWING NO.	OPERATING TIMES MINUTES T1	T2	T3-12	T13	TOT. OPER. HRS.	FAILURE RATE	ASSIGNED NO.	RELIABILITY
S	AFT TV CAM	03-0123-03	14.	14.	14.	14.	3.00	0.00333300	154	0.990051
M	PAN + TLT EQP	03-0123-04	10.	10.	10.	10.	2.20	0.00100000	190	0.997802
P	PAN + TLT EQP	03-0123-04	18.	8.	8.	8.	1.90	0.00100000	187	0.998102
N	PAN + TLT EQP	03-0123-04	14.	14.	14.	14.	3.00	0.00100000	184	0.997005
S	PAN + TLT EQP	03-0123-04	14.	14.	14.	14.	3.00	0.00100000	192	0.997005
N	HMG BEAC	03-0131-02	153.	143.	143.	117.	30.70	0.00010000	27	0.996935
N	BEAC REL	03-0131-03	7.	7.	7.	7.	1.50	0.00002000	23	0.999970
N	FORE LIGHTS	03-0138-01	14.	14.	14.	14.	3.00	0.16660000	112	0.606652
S	FORE LIGHTS	03-0138-01	14.	14.	14.	14.	3.00	0.16660000	157	0.606652
N	TRAINABLE LIT	03-0138-02	14.	14.	14.	14.	3.00	0.16660000	123	0.606652
S	TRAINABLE LIT	03-0138-02	14.	14.	14.	14.	3.00	0.16660000	159	0.606652
P	TRAINABLE LIT	03-0138-02	18.	8.	8.	8.	1.90	0.16660000	188	0.728666
S	TRAINABLE LIT	03-0138-02	10.	10.	10.	10.	2.20	0.16660000	194	0.693142
N	800 WATT LITS	03-0138-03	14.	14.	14.	14.	3.00	0.01666000	121	0.951248
P	800 WATT LITS	03-0138-03	18.	8.	8.	8.	1.90	0.01666000	135	0.968842
M	800 WATT LITS	03-0138-03	20.	20.	20.	20.	4.40	0.01666000	148	0.929318
S	800 WATT LITS	03-0138-03	14.	14.	14.	14.	3.00	0.01666000	175	0.951248
M	SKIRT LIGHT	03-0138-04	20.	20.	20.	20.	4.40	0.16660000	146	0.480446
N	AFT LIGHTS	03-0138-05	14.	14.	14.	14.	3.00	0.16660000	122	0.606652
P	AFT LIGHTS	03-0138-05	18.	8.	8.	8.	1.90	0.16660000	134	0.728666
M	AFT LIGHTS	03-0138-05	20.	20.	20.	20.	4.40	0.16660000	147	0.480446
S	AFT LIGHTS	03-0138-05	14.	14.	14.	14.	3.00	0.16660000	176	0.606652
N	VER O A SONAR	03-0146-02	67.	67.	54.	54.	12.10	0.00250000	181	0.970203
N	HOR O A SONAR	03-0146-03	67.	67.	54.	54.	12.10	0.00250000	180	0.970203

LISTING OF COMPONENTS AND FAILURE RATES USED IN RELIABILITY COMPUTATION

FUNCTION	DESCRIPTION OF COMP.	DRAWING NO.	OPERATING TIMES MINUTES T1	T2	T3-12	T13	TOT. OPER. HRS.	FAILURE RATE	ASSIGNED NO.	RELIABILITY
N	ALT SONAR	03-0146-04	67.	67.	54.	54.	12.10	0.00333300	142	0.960473
N	DEPTH SONAR	03-0146-05	67.	67.	54.	54.	12.10	0.00333300	143	0.960473
N	SHORT R SONAR	03-0146-06	14.	14.	14.	14.	3.00	0.00250000	116	0.992528
P	SHORT R SONAR	03-0146-06	18.	8.	8.	8.	1.90	0.00250000	130	0.995261
M	SHORT R SONAR	03-0146-06	20.	20.	20.	20.	4.40	C.00250000	144	0.989060
S	SHORT R SONAR	03-0146-06	14.	14.	14.	14.	3.00	0.00250000	152	0.992528
N	DL HYDROPHONE	03-0162-07	55.	55.	42.	42.	9.50	0.00100000	114	0.990545
N	SKIRT PR GAGE	03-0162-08	67.	67.	54.	54.	12.10	0.00003300	115	0.999601
M	SKIRT PR GAGE	03-0162-08	31.	31.	31.	31.	6.80	0.00003300	141	0.999776
E	SKIRT PR GAGE	03-0162-08	19.	8.	8.	8.	1.90	0.00003300	163	0.999937
E	SKIRT PR GAGE	03-0162-08	116.	106.	93.	93.	20.40	0.00003300	172	0.999327
N	GYRO COMPASS	03-0172-02	191.	181.	168.	142.	36.50	0.00010000	30	0.996357
N	VERTICAL GYRO	03-0172-04	191.	181.	168.	142.	36.50	0.00010000	32	0.996357
N	SONAR CTL + D	03-0201	67.	67.	54.	54.	12.10	0.00200000	196	0.976090
N	SONAR CTL + D	03-0201	14.	14.	14.	14.	3.00	0.00200000	197	0.994018
P	SONAR CTL + D	03-0201	8.	8.	8.	8.	1.90	0.00200000	198	0.996207
M	SONAR CTL + D	03-0201	20.	20.	20.	20.	4.40	0.00200000	199	0.991239
S	SONAR CTL + D	03-0201	14.	14.	14.	14.	3.00	0.00200000	200	0.994018
M	SKIRT XFR C+D	03-0232/35	20.	20.	20.	20.	4.40	0.00000510	138	0.999978
N	COM SYS C + D	03-0210/15	55.	55.	42.	42.	9.50	0.00008100	126	0.999231
C	COM SYS C + D	03-0210/15	141.	131.	118.	118.	26.10	0.00008100	127	0.997888
M	COM SYS C + D	03-0210/15	10.	10.	10.	10.	2.20	0.00008100	174	0.999822
S	COM SYS C + D	03-0210/15	14.	14.	14.	14.	3.00	0.00008100	158	0.999757
N	COM SYS C + D	03-0210/15	14.	14.	14.	14.	3.00	0.00008100	182	0.999757

LISTING OF COMPONENTS AND FAILURE RATES USED IN RELIABILITY COMPUTATION

FUNCTION	DESCRIPTION OF COMP.	DRAWING NO.	OPERATING TIMES MINUTES T1	T2	T3-12	T13	TOT. OPER. HRS.	FAILURE RATE	ASSIGNED NO.	RELIABILITY
V	RES BAL+JET	C03-0222/24	75.	75.	75.	49.	15.80	0.00003520	18	0.999444
N	TV CAM C + D	03-0225/27	14.	14.	14.	14.	3.00	0.00021000	183	0.999370
P	TV CAM C + D	03-0225/27	18.	8.	8.	8.	1.90	0.00021000	186	0.999601
M	TV CAM C + D	03-0225/27	10.	10.	10.	10.	2.20	0.00021000	191	0.999538
S	TV CAM C + D	03-0225/27	14.	14.	14.	14.	3.00	0.00021000	193	0.999370
M	TV CAM C + D	03-0225/27	14.	14.	14.	14.	3.00	0.00021000	201	0.999370
V	EXT BAL+JET	C03-0236/40	58.	58.	56.	43.	11.90	0.00003520	17	0.999581
N	NAV COMP	03-0250	55.	55.	42.	42.	9.50	0.00000700	24	0.999934
K	MERC TRIM S	M03-0250-01	100.	90.	77.	77.	17.20	0.00000700	58	0.999880
K	LIFE SUPPORT	03-0250-02	141.	131.	118.	118.	26.10	0.00000700	59	0.999817
K	EXTER BALLAST	03-0250-03	8.	8.	8.	8.	1.60	0.00000700	60	0.999989
K	CONT PROPUL	03-0250-04	69.	67.	57.	57.	12.60	0.00000700	61	0.999912
K	PWR DISTRIB	03-0250-05	191.	181.	168.	142.	36.50	0.00000700	62	0.999745
K	EX SNSRS	03-0250-06	191.	181.	168.	142.	36.50	0.00000700	63	0.999745
K	INT SNSR	03-0250-07	191.	181.	168.	142.	36.50	0.00000700	64	0.999745
K	STRUCTURES	03-0250-08	49.	39.	39.	39.	8.60	0.00000700	65	0.999940
V	MERC TRIM C+D	03-0255/59	100.	90.	77.	77.	17.20	0.00005780	11	0.999006
V	PRPL SYS C+D	03-0280/84	67.	65.	54.	54.	12.10	0.00016800	12	0.997969
N	EXT SENS DISP	03-0285/89	67.	67.	54.	54.	12.10	0.00002100	161	0.999746
V	EXT SENS DISP	03-0285/89	100.	90.	77.	77.	17.20	0.00002100	195	0.999639
E	EXT SENS DISP	03-0285/89	19.	8.	8.	8.	1.90	0.00002100	164	0.999960
E	EXT SENS DISP	03-0285/89	116.	106.	93.	93.	20.40	0.00002100	173	0.999572
M	EXT SENS DISP	03-0285/89	31.	31.	31.	31.	6.80	0.00002100	162	0.999857
D	CAPSULE STRUC	03-0301/10	191.	181.	168.	142.	36.50	0.00001500	33	0.999453

LISTING OF COMPONENTS AND FAILURE RATES USED IN RELIABILITY COMPUTATION

FUNCTION	DESCRIPTION OF COMP.	DRAWING NO.	OPERATING TIMES MINUTES T1	T2	T3-12	T13	TOT. OPER. HRS.	FAILURE RATE	ASSIGNED NO.	RELIABILITY
D	INT STRUCTURE	03-0311/20	191.	181.	168.	142.	36.50	0.00001500	124	0.999453
D	ACCESS HATCH	03-0321/30	191.	181.	168.	142.	36.50	0.00001500	35	0.999453
D	ELECT PENET	03-0331/40	191.	181.	168.	142.	36.50	0.00001500	36	0.999453
N	VIEWPT OPTICS	03-0341	14.	14.	14.	14.	3.00	0.00001500	120	0.999955
P	VIEWPT OPTICS	03-0341	18.	8.	8.	8.	1.90	0.00001500	131	0.999972
M	VIEWPT OPTICS	03-0341	10.	10.	10.	10.	2.20	0.00001500	150	0.999967
S	VIEWPT OPTICS	03-0341	14.	14.	14.	14.	3.00	0.00001500	177	0.999955
D	OPTICAL PENET	C3-0341/50	191.	181.	168.	142.	36.50	0.00001500	37	0.999453
V	MAIN PROP SYS	03-0401	67.	65.	54.	54.	12.10	0.00005030	7	0.999392
D	OUT HULL+FRAM	03-0405	191.	181.	168.	142.	36.50	0.00000170	38	0.999938
B	MAIN BATT	03-04101-1	191.	181.	168.	142.	36.50	0.00023670	85	0.991398
B	AUX BATT	03-04101-2	191.	181.	168.	142.	36.50	0.00025060	84	0.990895
P	MANIP+TOOL JE	03-0415	18.	8.	8.	8.	1.90	0.00024250	44	0.999539
M	ANCHORS + MAR	03-0425	37.	37.	37.	37.	8.00	0.00333300	139	0.973688
V	MERCURY TRIM	03-0430	100.	90.	77.	77.	17.20	0.00006570	10	0.998871
V	BALLAST SYS	03-0435	33.	33.	31.	31.	6.70	0.00007220	16	0.999516
D	FLOT MATERIAL	03-0440	191.	181.	168.	142.	36.50	0.00000100	39	0.999964
M	SKIRT DEWATER	03-0445/49	20.	20.	20.	20.	4.40	0.00010200	140	0.999551
V	HYDRAULIC PWR	03-0450/54	42.	40.	34.	34.	7.50	0.00009380	110	0.999297
P	HYDRAULIC PWR	03-0450/54	18.	8.	8.	8.	1.90	0.00009380	129	0.999822
H	HYDRAULIC PWR	03-0450/54	99.	91.	84.	84.	18.60	0.00009380	160	0.998257
H	HYDRAULIC PWR	03-0450/54	141.	131.	118.	118.	26.10	0.00009380	171	0.997555
M	MATING SYSTEM	03-0455	20.	20.	20.	20.	4.40	0.00006400	136	0.999718
M	SKIRT SEAL	03-0459	91.	91.	91.	66.	19.30	0.00019530	137	0.996238

LISTING OF COMPONENTS AND FAILURE RATES USED IN RELIABILITY COMPUTATION

FUNCTION	DESCRIPTION OF COMP. DRAWING NO.	OPERATING TIMES MINUTES T1	T2	T3-12	T13	TOT. OPER. HRS.	FAILURE RATE	ASSIGNED NO.	RELIABILITY
V	PROPELLER S+B03-0475	69.	67.	57.	57.	12.60	0.00000300	8	0.999962
V	SHROUD RDR+AC03-0480/84	42.	40.	34.	34.	7.50	0.00003650	9	0.999726
V	THRUSTERS + C03-0490	42.	40.	34.	34.	7.50	0.00026640	13	0.998004
L	C S 02 ST C+D03-0601/04	141.	131.	118.	118.	26.10	0.00007700	69	0.997992
L	C S C02 REMOV03-0605/09	141.	131.	118.	118.	26.10	0.00001000	70	0.999739
L	CS TOXICS C+D03-0605/09	141.	131.	118.	118.	26.10	0.00001000	74	0.999739
L	R S C02 REMOV03-0605/09	141.	131.	118.	118.	26.10	0.00001000	77	0.999739
L	RS TOXICS C+D03-0605/09	141.	131.	118.	118.	26.10	0.00001000	81	0.999739
L	C S HUMID C+D03-0610/14	141.	131.	118.	118.	26.10	0.00010100	71	0.997367
L	C S HELIUM C+03-0615/19	141.	131.	118.	118.	26.10	0.00000010	72	0.999997
L	C S TEMP+P C+03-0620/24	141.	131.	118.	118.	26.10	0.00008380	73	0.997815
L	ATMOS SAMPLE 03-0630/34	3.	3.	3.	3.	0.65	0.00001500	202	0.999990
L	R S 02 ST C+D03-0635/39	87.	85.	82.	82.	17.80	0.00007700	76	0.998630
L	R S HUMID C+D03-0645/49	87.	85.	82.	82.	17.80	0.00010100	78	0.998204
L	R S HELIUM C+03-0650/54	137.	135.	132.	106.	28.20	0.00000010	79	0.999997
L	R S TEMP+P C+03-0655/59	87.	85.	82.	82.	17.80	0.00008380	80	0.998509
L	R S PRESS SYS03-0665/69	87.	85.	82.	82.	17.80	0.00004400	82	0.999217

```
RELIABILITY FOR   VEH.CTL.+ PROPUL IS 0.988405
RELIABILITY FOR   NAVIG. + HOMING. IS 0.663193
RELIABILITY FOR   STRUCT.INTEGRITY IS 0.996622
RELIABILITY FOR    COMMUNICATION   IS 0.993423
RELIABILITY FOR     MANIPULATOR    IS 0.999360
RELIABILITY FOR   MATING + TRANSFR IS 0.464560
RELIABILITY FOR   SURVEIL.+SEARCH. IS 1.000000
RELIABILITY FOR    COMPUTOR        IS 0.998772
RELIABILITY FOR    LIFE SUPPORT    IS 0.991124
RELIABILITY FOR   POWER AND DIST   IS 0.982371
RELIABILITY FOR   HYDRAULIC SYST.  IS 0.998257
RELIABILITY FOR   EXT SENS1000000+ IS 0.999897

..LIABILITY OF D.S.R.V. FOR 13 TRIP MISSION IS    0.292463
```

FUNCTIONAL RELIABILITY FOR	VEH.CTL.+ PROPUL	IS	0.988405
FUNCTIONAL RELIABILITY FOR	NAVIG. + HOMING.	IS	0.663193
FUNCTIONAL RELIABILITY FOR	STRUCT.INTEGRITY	IS	0.996622
FUNCTIONAL RELIABILITY FOR	COMMUNICATION	IS	0.991088
FUNCTIONAL RELIABILITY FOR	MANIPULATOR	IS	0.999360
FUNCTIONAL RELIABILITY FOR	MATING + TRANSFR	IS	0.464560
FUNCTIONAL RELIABILITY FOR	SURVEIL.+SEARCH.	IS	0.793586
FUNCTIONAL RELIABILITY FOR	COMPUTOR	IS	0.998705
FUNCTIONAL RELIABILITY FOR	LIFE SUPPORT	IS	0.991124
FUNCTIONAL RELIABILITY FOR	POWER AND DIST	IS	0.982371
FUNCTIONAL RELIABILITY FOR	HYDRAULIC SYST.	IS	0.997555
FUNCTIONAL RELIABILITY FOR	EXT SENS1000000+	IS	0.998899

Appendix E

Listing of Second DSRV Model Input Data in Order of Assigned Number

(The assigned numbers are contained in the three right-hand columns.)

F	Desciption of Comp.	Drawing Number	T1	T2	T3-T12	T13	Total Oper. Time	Failure Rate	Assigned Number
V	MAIN PROP SYS	03-0401	67.	65.	54.	54.	12.10	.00061070	.0000503007
V	PRCPELLER S+B	03-0475	69.	67.	57.	57.	12.60	.00003790	.0000030008
V	SHROUD RDR+AC	03-0480/84	42.	40.	34.	34.	7.50		.0000365009
V	MERCURY TRIM	03-0430	100.	90.	77.	77.	17.20	.00113620	.0000657010
V	MERC TRIM C+D	03-0255/59	100.	90.	77.	77.	17.20	.00099970	.0000578011
V	PRPL SYS C+D	03-0280/84	67.	65.	54.	54.	12.10		.0001680012
V	THRUSTERS + C	03-0490	42.	40.	34.	34.	7.50	.00199980	.0002664013
V	MTN + DPTH SE	03-0108-14	100.	90.	77.	77.	17.20		.0002930014
V	BALLAST SYS	03-0435	33.	33.	31.	31.	6.70	.00048810	.0000722016
V	EXT BAL+JET C	03-0236/40	58.	58.	56.	43.	11.90	.00042150	.0000352017
V	RES BAL+JET C	03-0222/24	75.	75.	75.	49.	15.80	.00055740	.0000352018
N	COPP NAV	03-0108-01	49.	49.	36.	36.	8.30	.01664000	.0020000019
N	DEAD RECK TRC	03-0108-02	55.	55.	42.	42.	9.50	.00095330	.0001000020
N	RATE GYRO PKG	03-0108-04	191.	181.	168.	142.	36.50	.00219400	.0000600022
N	BEAC REL	03-0131-03	7.	7.	7.	7.	1.50	.00003030	.0000200023
N	NAV COMP	03-0250	55.	55.	42.	42.	9.50	.00006670	.0000070024
N	HMG BEAC	03-0131-02	153.	143.	143.	117.	30.70	.00307170	.0001000027
N	NAV DISP	03-0108-07	55.	55.	42.	42.	9.50	.00010270	.0000108028
N	GYRO COMPASS	03-0172-02	191.	181.	168.	142.	36.50	.00365670	.0001000030
N	VERTICAL GYRO	03-0172-04	191.	181.	168.	142.	36.50	.00365670	.0001000032
O	CAPSULE STRUC	03-0301/10	191.	181.	168.	142.	36.50		.0000150033
O	ACCESS HATCH	03-0321/30	191.	181.	168.	142.	36.50		.0000150035
O	ELECT PENET	03-0331/40	191.	181.	168.	142.	36.50		.0000150036
O	OPTICAL PENET	03-0341/50	191.	181.	168.	142.	36.50		.0000150037
O	OUT HULL+FRAM	03-0405	191.	181.	168.	142.	36.50	.00006110	.0000017038
O	FLOT MATERIAL	03-0440	191.	181.	168.	142.	36.50	.00003660	.0000010039
M	SKIRT DEWATER	03-0445/49	20.	20.	20.	20.	4.40		.0001020140
P	MANIP+TOOL JE	03-0415	18.	8.	8.	8.	1.90	.00046070	.0002425044
K	MERC TRIM S M	03-0250-01	100.	90.	77.	77.	17.20	.00012100	.0000070058
K	LIFE SUPPORT	03-0250-02	141.	131.	118.	118.	26.10	.00018320	.0000070059
K	EXTER BALLAST	03-0250-03	8.	8.	8.	8.	1.60	.00001150	.0000070060
K	CONT PROPUL	03-0250-04	69.	67.	57.	57.	12.60	.00008880	.0000070061
K	PWR DISTRIB	03-0250-05	191.	181.	168.	142.	36.50	.00025600	.0000070062
K	EX SNSRS	03-0250-06	191.	181.	168.	142.	36.50	.00025600	.0000070063
K	INT SNSR	03-0250-07	191.	181.	168.	142.	36.50	.00025600	.0000070064
K	STRUCTURES	03-0250-08	49.	39.	39.	39.	8.60	.00006030	.0000070065
L	C S 02 ST C+D	03-0601/04	141.	131.	118.	118.	26.10	.00201480	.0000770069
L	C S CO2 REMOV	03-0605/09	141.	131.	118.	118.	26.10		.0000100070
L	C S HUMID C+D	03-0610/14	141.	131.	118.	118.	26.10	.00264280	.0001010071
L	C S HELIUM C+	03-0615/19	141.	131.	118.	118.	26.10	.00000370	.0000001072

F	Desciption of Comp.	Drawing Number	T1	T2	T3-T12	T13	Total Oper. Time	Failure Rate		Assigned Number
L	C S TEMP+P C+	03-0620/24	141.	131.	118.	118.	26.10	.00219280	.0000838	073
L	CS TOXICS C+D	03-0605/09	141.	131.	118.	118.	26.10		.0000100	074
L	R S 02 ST C+D	03-0635/39	87.	85.	82.	82.	17.80	.00137730	.0000770	076
L	R S CO2 REMOV	03-0605/09	141.	131.	118.	118.	26.10		.0000100	077
L	R S HUMID C+D	03-0645/49	87.	85.	82.	82.	17.80	.00180660	.0001010	078
L	R S HELIUM C+	03-0650/54	137.	135.	132.	106.	28.20	.00000400	.0000001	079
L	R S TEMP+P C+	03-0655/59	87.	85.	82.	82.	17.80	.00149890	.0000838	080
L	RS TOXICS C+D	03-0605/09	141.	131.	118.	118.	26.10		.0000100	081
~~L~~	~~R S PRESS SYS~~	~~03-0665/69~~	~~87.~~	~~85.~~	82.	82.	17.80	.00078700	.0000440	082
B	AUX BATT	03-04101-2	191.	181.	168.	142.	36.50	.00916360	.00[illegible]2506	084
B	MAIN BATT	03-04101-1	191.	181.	168.	142.	36.50	.00865390	.0002367	085
V	HYDRAULIC PWR	03-0450/54	42.	40.	34.	34.	7.50		.0000938	110
N	FORE TV CAM	03-0123-01	14.	14.	14.	14.	3.00		.0033330	111
N	FORE LIGHTS	03-0138-01	14.	14.	14.	14.	3.00		.1666000	112
N	U/W PHONE	03-0101-01	55.	55.	42.	42.	9.50		.0002220	113
N	DL HYDROPHONE	03-0162-07	55.	55.	42.	42.	9.50		.0010000	114
N	SKIRT PR GAGE	03-0162-08	67.	67.	54.	54.	12.10		.0000330	115
N	SHORT R SONAR	03-0146-06	14.	14.	14.	14.	3.00		.0025000	116
N	SKIRT TV CAM	03-0123-02	14.	14.	14.	14.	3.00		.0000180	117
N	AFT TV CAM	03-0123-03	14.	14.	14.	14.	3.00		.0033330	118
N	HATCH PH + 1C	03-0101-02	14.	14.	14.	14	3.00		.0000400	119
N	VIEWPT OPTICS	03-0341	14.	14.	14.	14.	3.00		.0000150	120
N	800 WATT LITS	03-0138-03	14.	14.	14.	14.	3.00		.0166600	121
N	AFT LIGHTS	03-0138-05	14.	14.	14.	14.	3.00		.1666000	122
N	TRAINABLE LIT	03-0138-02	14.	14.	14.	14.	3.00		.1666000	123
O	INT STRUCTURE	03-0311/20	191.	181.	168.	142.	36.50		.0000150	124
C	U/W PHONE	03-0101-01	81.	71.	71.	71.	15.50		.0002220	125
N	COM SYS C + D	03-0210/15	55.	55.	42.	42.	9.50		.0000810	126
C	COM SYS C + D	03-0210/15	141.	131.	118.	118.	26.10		.0000810	127
C	HATCH PH + 1C	03-0101-02	141.	131.	118.	118.	26.10		.0000400	128
P	HYDRAULIC PWR	03-0450/54	18.	8.	8.	8.	1.90		.0000938	129
P	SHORT R SONAR	03-0146-06	18.	8.	8.	8.	1.90		.0025000	130
P	VIEWPT OPTICS	03-0341	18.	8.	8.	8.	1.90		.0000150	131
P	SKIRT TV CAM	03-0123-02	18.	8.	8.	8.	1.90		.0000180	132
P	AFT TV CAM	03-0123-03	18.	8.	8.	8.	1.90		.0033330	133
P	AFT LIGHTS	03-0138-05	18.	8.	8.	8.	1.90		.1666000	134
P	800 WATT LITS	03-0138-03	18.	8.	8.	8.	1.90		.0166600	135
M	MATING SYSTEM	03-0455	20.	20.	20.	20.	4.40		.0000640	136
M	SKIRT SEAL	03-0459	91.	91.	91.	66.	19.30		.0001953	137
M	SKIRT XFR C+D	03-0232/35	20.	20.	20.	20.	4.40		.0000051	138

T	Description of Comp.	Drawing Number	T1	T2	T3-T12	T13	Total Oper. Time	Failure Rate	Assigned Number
M	ANCHORS + MAR	03-0425	37.	37.	37.	37.	8.00		.0033330139
M	SKIRT PR GAGE	03-0162-08	31.	31.	31.	31.	6.80		.0000330141
M	ALT SONAR	03-0146-04	67.	67.	54.	54.	12.10		.0033330142
M	DEPTH SONAR	03-0146-05	67.	67.	54.	54.	12.10		.0033330143
M	SHORT R SONAR	03-0146-06	20.	20.	20.	20.	4.40		.0025000144
M	SKIRT TV CAM	03-0123-02	20.	20.	20.	20.	4.40		.0000180145
M	SKIRT LIGHT	03-0138-04	20.	20.	20.	20.	4.40		.1666000146
M	AFT LIGHTS	03-0138-05	20.	20.	20.	20.	4.40		.1666000147
M	800 WATT LITS	03-0138-03	20.	20.	20.	20.	4.40		.0166600148
M	AFT TV CAM	03-0123-03	20.	20.	20.	20.	4.40		.0033330149
M	VIEWPT(PTICS	03-0341	10.	10.	10.	10	2.20		.0000150150
M	HATCH PH + 1C	03-0101-02	10.	10.	10.	10.	2.20		.0000400151
S	SHORT R SONAR	03-0146-06	14.	14.	14.	14.	3.00		.0025000152
S	SKIRT TV CAM	03-0123-02	14.	14.	14.	14.	3.00		.0000180153
S	AFT TV CAM	03-0123-03	14.	14.	14.	14.	3.00		.0033330154
S	HATCH PH + 1C	03-0101-02	14.	14.	14.	14.	3.00		.0000400155
S	FORE TV CAM	03-0123-01	27.	27.	14.	14.	3.50		.0033330156
S	FORE LIGHTS	03-0138-01	14.	14.	14.	14.	3.00		.1666000157
S	COM SYS C + D	03-0210/15	14.	14.	14.	14.	3.00		.0000810158
S	TRAINABLE LIT	03-0138-02	14.	14.	14.	14.	3.00		.1666000159
M	HYDRAULIC PWR	03-0450/54	99.	91.	84.	84.	18.60		.0000938160
M	EXT SENSDISP	03-0285/89	67.	67.	54.	54.	12.10		.0000210161
M	EXT SENS DISP	03-0285/89	31.	31.	31.	31.	6.80		.0000210162
E	SKIRT PR GAGE	03-0162-08	19.	8.	8.	8.	1.90		.0000330163
E	EXT SENS DISP	03-0285/89	19.	8.	8.	8.	1.90		.0000210164
C	U/W PHONE	03-0101-01	141.	131.	118.	118.	26.10		.0002220170
M	HYDRAULIC PWR	03-0450/54	141.	131.	118.	118.	26.10		.0000938171
E	SKIRT PR GAGE	03-0162-08	116.	106.	93.	93.	20.40		.0000330172
E	EXT SENS DISP	03-0285/89	116.	106.	93.	93.	20.40		.0000210173
M	COM SYS C + D	03-0210/15	10.	10.	10.	10.	2.20		.0000810174
S	800 WATT LITS	03-0138-03	14.	14.	14.	14.	3.00		.0166600175
S	AFT LIGHTS	03-0138-05	14.	14.	14.	14.	3.00		.1666000176
S	VIEWPT OPTICS	03-0341	14.	14.	14.	14.	3.00		.0000150177
N	HOR O A SONAR	03-0146-03	67.	67.	54.	54.	12.10		.0025000180
N	VER O A SONAR	03-0146-02	67.	67.	54.	54.	12.10		.0025000181
N	COM SYS C + D	03-0210/15	14.	14.	14.	14.	3.00		.0000810182
N	TV CAM C + D	03-0225/27	14.	14.	14.	14.	3.00		.0002100183
N	PAN + TLT EQP	03-0123-04	14.	14.	14.	14.	3.00		.0010000184
P	FORE TV CAM	03-0123-01	18.	8.	8.	8.	1.90		.0033330185
P	TV CAM C + D	03-0225/27	18.	8.	8.	8.	1.90		.0002100186

F	DESCRIPTION OF COMP.	DRAWING NUMBER	T1	T2	T3-T12	T13	TOTAL OPER. TIME	FAILURE RATE	ASSIGNED NUMBER
P	PAN + TLT EQP	03-0123-04	18.	8.	8.	8.	1.90	.0010000	187
P	TRAINABLE LIT	03-0138-02	18.	8.	8.	8.	1.90	.1666000	188
M	FORE TV CAM	03-0123-01	10.	10.	10.	10.	2.20	.0033330	189
M	PAN + TLT EQP	03-0123-04	10.	10.	10.	10.	2.20	.0010000	190
M	TV CAM C + D	03-0225/27	10.	10.	10.	10.	2.20	.0002100	191
S	PAN + TLT EQP	03-0123-04	14.	14.	14.	14.	3.00	.0010000	192
S	TV CAM C + D	03-0225/27	14.	14.	14.	14.	3.00	.0002100	193
S	TRAINABLE LIT	03-0138-02	10.	10.	10.	10.	2.20	.1666000	194
V	EXTSENSDISP	03-0285/89	100.	90.	77.	77.	17.20	.0000210	195
N	SONAR CTL + D	03-0201	67.	67.	54.	54.	12.10	.0020000	196
N	SONAR CTL + D	03-0201	14.	14.	14.	14.	3.00	.0020000	197
P	SONAR CTL + D	03-0201	8.	8.	8.	8.	1.90	.0020000	198
M	SONAR CTL + D	03-0201	20.	20.	20.	20.	4.40	.0020000	199
S	SONAR CTL + D	03-0201	14.	14.	14.	14.	3.00	.0020000	200
M	TV CAM C + D	03-0225/27	14.	14.	14.	14.	3.00	.0002100	201
L	ATMOS SAMPLE	03-0630/34	3.	3.	3.	3.	0.65	.0000150	202
L	HATCH PM +IC	03-0101-02	3.	3.	3.	3.	0.65	.0000400	203

Appendix F

Changes to Input Data Used in Second DSRV Reliability Model

A. Component Failure Rates in Error in First Model

Assigned No.	Description of Component	Failure Rate (Per 10^6 Hrs.) Changed From	To
012	Propulsion System Cont. & Disp.	57.8	168*
033	Capsule Structure	10	15
035	Access Hatch	1	15
036	Electrical Penetrations	0.1	15
037	Optical Penetrations	0.1	15
070	Control Sphere CO_2 Removal	0.2	10
074	Control Sphere Toxics Cont. and Disp.	0.2	10
077	Rescue Sphere CO_2 Removal	0.2	10
081	Rescue Sphere Toxics Cont. and Disp.	0.2	10
111	Fore TV Camera	3300	3333
133	Aft TV Camera	3300	3333

* The Reliability Data supplement to ARINC's 30 June 1965 report, Deep Submergence Rescue Vehicle Equipments Reliability Predictions and Allocations, is used as the source of correct failure rates for the first reliability model.

B. Component Failure Rates Changed by Latest Information

Assigned No.	Description of Component	Failure Rate (Per 10^6 Hrs.) Changed From	To
112	Fore Lights*	3300	166,600
157	Fore Lights	3300	166,600
113	Underwater Phone	500	222
125	Underwater Phone	500	222
170	Underwater Phone	500	222
121	800-Watt Light	500	16,660
135	800-Watt Light	500	16,660
148	800-Watt Light	500	16,660
175	800-Watt Light	500	16,660
122	Aft Lights	3333	16,660
134	Aft Lights	3333	16,660
147	Aft Lights	3333	16,660
176	Aft Lights	3333	16,660
123	Trainable Light	3333	16,660
159	Trainable Light	3333	16,660
188	Trainable Light	3333	16,660
194	Trainable Light	3333	16,660
146	Skirt Light	250,000	166,600

* Light failure rate based on information from M. Goodman of NASL. Underwater Phone failure rate from S. Keller of NASL.

C. Component Failure Rates Added in Second Model

Assigned No.	Description of Component	Failure Rate (Per 10^6 Hrs.)
120	Viewport Optics	15*
131	Viewport Optics	15
150	Viewport Optics	15
177	Viewport Optics	15
137	Skirt Seal	195.3
184	Pan and Tilt Equipment	3.0
187	Pan and Tilt Equipment	1.9
190	Pan and Tilt Equipment	2.2
192	Pan and Tilt Equipment	3.0

* The computer program for the first reliability model, and not the 30 June 1965 ARINC report, defines the components which were included in the first model computations.

D. Component Operating Times Changed in Second Model

Assigned No.	Description of Component	Operating Times (Hrs.) Changed From	To
110	Hydraulic Power	26.1	7.5*
129	Hydraulic Power	26.1	1.9
160	Hydraulic Power	26.1	18.6
171	Hydraulic Power	26.1	26.1
114	Directional Listening Hydrophone	6.1	9.5
115	Skirt Pressure Gauge	3.4	12.1
141	Skirt Pressure Gauge	3.4	6.8
163	Skirt Pressure Gauge	3.4	1.9
172	Skirt Pressure Gauge	3.4	20.4
116	Short Range Sonar	6.8	3.0
130	Short Range Sonar	6.8	1.9
144	Short Range Sonar	6.8	4.4
152	Short Range Sonar	6.8	3.0
117	Skirt TV Camera	8.8	3.0
132	Skirt TV Camera	8.8	1.9
145	Skirt TV Camera	8.8	4.4
153	Skirt TV Camera	8.8	3.0
119	Hatch Phone and Intercom	18.5	3.0
128	Hatch Phone and Intercom	18.5	26.1
151	Hatch Phone and Intercom	18.5	2.2
155	Hatch Phone and Intercom	18.5	3.0
124	Internal Structure	18.2	36.5
126	Communication System Cont. and Disp.	22.2	9.5
127	Communication System Cont. and Disp.	22.2	26.1
158	Communication System Cont. and Disp.	22.2	3.0
174	Communication System Cont. and Disp.	22.2	2.2
182	Communication System Cont. and Disp.	22.2	3.0
136	Mating System	5.7	4.4
138	Skirt Transfer Cont. and Display	3.9	4.4
139	Anchors and Markers	5.9	8.0
140	Skirt Dewatering System	5.6	4.4
142	Altitude Sonar	12.6	12.1

* New operating times are based on battery and hydraulic power supply power-profiles in the vehicle RFP.

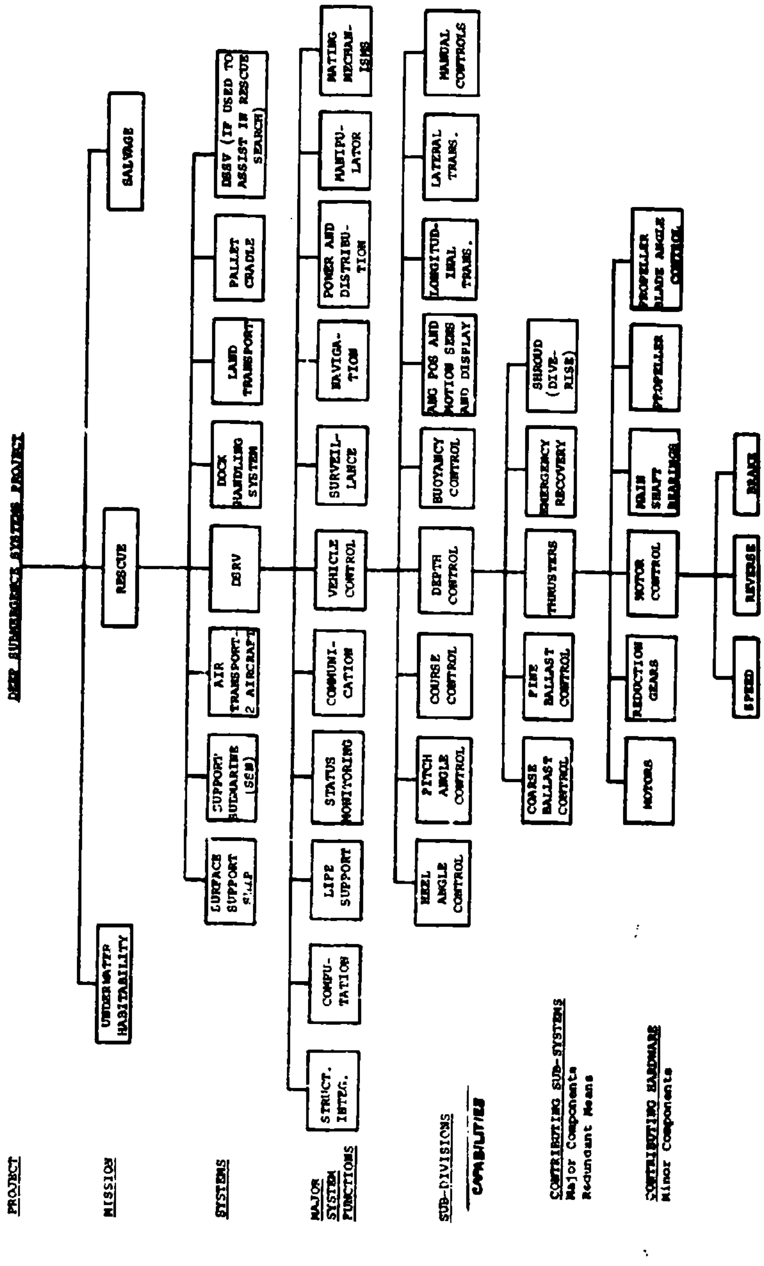
D. Component Operating Times Changed in Second Model (cont'd.)

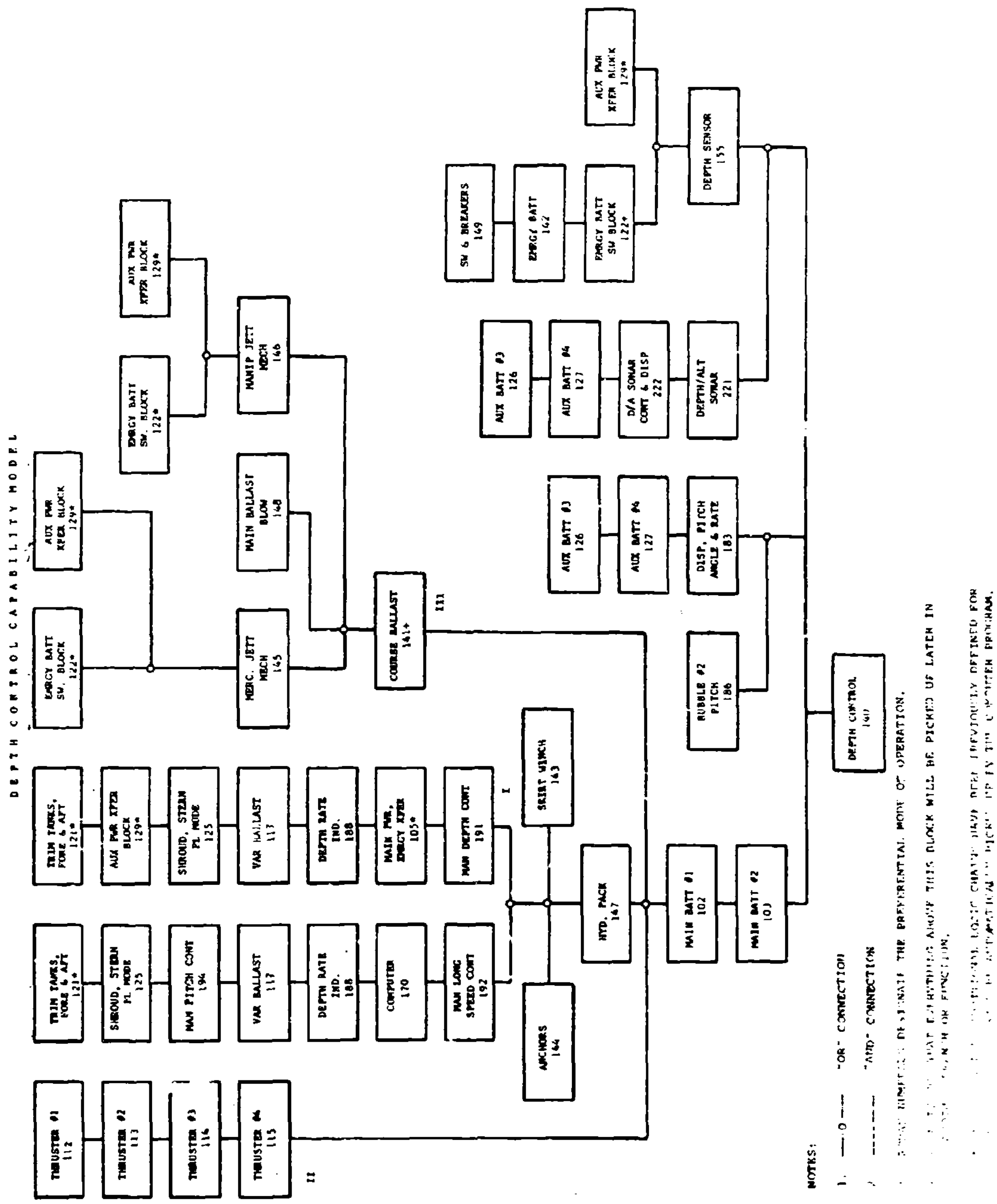
Assigned No.	Description of Component	Operating Times (Hrs.) Changed From	To
143	Depth Sonar	12.6	12.1
161	External Sensors Disp.	7.0	12.1
162	External Sensors Disp.	7.0	6.8
164	External Sensors Disp.	7.0	1.9
173	External Sensors Disp.	7.0	20.4
195	External Sensors Disp.	7.0	17.2
180	Horizontal Obstacle Avoid. Sonar	12.6	12.1
181	Vertical Obstacle Avoid. Sonar	12.6	12.1
183	TV Camera Cont. and Disp.	9.3	3.0
186	TV Camera Cont. and Disp.	9.3	1.9
191	TV Camera Cont. and Disp.	9.3	2.2
193	TV Camera Cont. and Disp.	9.3	3.0
201	TV Camera Cont. and Disp.	9.3	3.0
196	Sonar Cont. and Disp.	13.1	12.1
197	Sonar Cont. and Disp.	13.1	3.0
198	Sonar Cont. and Disp.	13.1	1.9
199	Sonar Cont. and Disp.	13.1	4.4
200	Sonar Cont. and Disp.	13.1	3.0
202	Atmosphere Sampling	6.0	.65
203	Hatch Phone and Intercom	18.5	.65

Appendix G

Recommendation for Modeling of the DSRV in an Advanced Reliability Study

DSRV SYSTEM STRUCTURE FOR ADVANCED RELIABILITY STUDY




DEPTH CONTROL CAPABILITY MODEL
THRUSTER #1 112
THRUSTER #2 113
THRUSTER #3 114
THRUSTER #4 115
TRIM TANKS, FORE & AFT 121*
SHROUD, STERN PL MODE 125
MAN PITCH CONT 194
VAR BALLAST 117
DEPTH RATE IND. 188
COMPUTER 170
MAN LONG SPEED CONT 192
AUX PWR XFER BLOCK 129*
MAIN PWR, EMRGY XFER 105*
MAN DEPTH CONT 191
ANCHORS 144
SKIRT WINCH 143
HYD. PACK 147
MAIN BATT #1 102
MAIN BATT #2 103
EMRGY BATT SW. BLOCK 122*
MERC. JETT MECH 145
MAIN BALLAST BLOW 148
MANIP JETT MECH 146
COURSE BALLAST 141+
SW & BREAKERS 149
EMRGY BATT 142
DEPTH SENSOR 155
AUX BATT #3 126
AUX BATT #4 127
D/A SONAR CONT & DISP 222
DEPTH/ALT SONAR 221
DISP, PITCH ANGLE & RATE 183
BUBBLE #2 PITCH 186
DEPTH CONTROL
NOTES:
"OR" CONNECTION
"AND" CONNECTION

BOOLEAN EXPRESSION AND PROBABILITY EQUATION FOR A PORTION OF THE DEPTH CONTROL MODEL

A. BOOLEAN EXPRESSION

$$141^* = 141 \left\{ [145\ (122\ V\ 129)]\ V\ [146\ (122\ V\ 129)]\ V\ [148] \right\}$$

Where V designates "or", and "and" is indicated by multiplication.
This expression is simplified to the following:

$$141^* = 141 \left\{ (122\ V\ 129)\ (145\ V\ 146)\ V\ 148 \right\}$$

B. RELIABILITY EQUATION

$$Pr\ [141^*] = P141\ \left\{ 1- \left[1- (1-(1-P122)(1-P129)) (1-(1-P145)(1-P146)) \right] \left[1-P148 \right] \right\}$$

Where Pr and P represent probability.

Security Classification Unclassified

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 Marine Engineering Laboratory Deep Submergence Systems Project Interface	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

Reliability Prediction for a Deep Submergence Rescue Vehicle; Second Reliability Model

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

5. AUTHOR(S) *(Last name, first name, initial)*

Ragot, Robert L.
Hamilton, Robert L.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
March, 1966	47	5

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. 62-701-300	110/66
c.	9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*
d.	Assignment 62 701

10. AVAILABILITY/LIMITATION NOTICES

Each transmittal of this document outside the agencies of the U. S. Government must have prior approval of Chief, Bureau of Ships, USN, (Code 210L), Washington, D. C. 20360

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Special Projects Office NAVSHIPS

13. ABSTRACT

A second reliability model of the Deep Submergence Rescue Vehicle (DSRV) is defined. On the basis of this model, a prediction is made of the DSRV reliability for a typical rescue mission. The predicted reliability is computed to be 29%, for a 26-hour vehicle-operating time. The major factor contributing to the low predicted reliability of the vehicle is the high failure rate assumed for the forward and skirt (exterior) lamps. A two-orders-of-magnitude decrease in the assumed failure rate for these underwater lamps results in a predicted reliability of about 80%. Recommendations are made for improving future DSRV reliability studies.

(by author)

Security Classification Unclassified

14. KEY WORDS	LINK A ROLE	LINK A WT	LINK B ROLE	LINK B WT	LINK C ROLE	LINK C WT
Reliability						
Prediction of system reliability						
Deep Submergence						
Submarine						
Mathematical model						
Trade-offs						

INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization *(corporate author)* issuing the report.

2a. REPORT SECURITY CLASSIFICATION: Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2b. GROUP: Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. REPORT TITLE: Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. DESCRIPTIVE NOTES: If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. AUTHOR(S): Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. REPORT DATE: Enter the date of the report as day, month, year, or month, year. If more than one date appears on the report, use date of publication.

7a. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. NUMBER OF REFERENCES: Enter the total number of references cited in the report.

8a. CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which the report was written.

8b, 8c, & 8d. PROJECT NUMBER: Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9a. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9b. OTHER REPORT NUMBER(S): If the report has been assigned any other report numbers *(either by the originator or by the sponsor)*, also enter this number(s).

10. AVAILABILITY/LIMITATION NOTICES: Enter any limitations on further dissemination of the report, other than those imposed by security classification, using standard statements such as:

(1) "Qualified requesters may obtain copies of this report from DDC."

(2) "Foreign announcement and dissemination of this report by DDC is not authorized."

(3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through ________________."

(4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through ________________."

(5) "All distribution of this report is controlled. Qualified DDC users shall request through ________________."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.

12. SPONSORING MILITARY ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring *(paying for)* the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as *(TS), (S), (C), or (U)*.

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, roles, and weights is optional.

Navy Marine Engineering Laboratory.
Report 110/66.
RELIABILITY PREDICTION FOR A DEEP SUBMERGENCE RESCUE VEHICLE; SECOND RELIABILITY MODEL, by R. L. Ragot and R. L. Hamilton
March 1966. 47 pp.
Figs. UNCLASSIFIED

1. DSRV - Reliability Pred.
2. Deep Submerge. - Rescue Veh - Reliab. Pred.
3. Rescue Veh.
I. Hamilton, R.L.
II. Ragot, R. L.
III. Title

A second reliability model of the Deep Submergence Rescue Vehicle (DSRV) is defined. On (over)

UNCLASSIFIED

the basis of this model, a prediction is made of the DSRV reliability for a typical rescue mission. The predicted reliability is computed to be 29%, for a 26-hour vehicle-operating time. The major factor contributing to the low predicted reliability of the vehicle is the high failure rate assumed for the forward and skirt (exterior) lamps. A two-orders-of-magnitude decrease in the assumed failure rate for these underwater lamps results in a predicted reliability of about 80%. Recommendations are made for improving future DSRV reliability studies.

Navy Marine Engineering Laboratory.
Report 110/66.
RELIABILITY PREDICTION FOR A DEEP SUBMERGENCE RESCUE VEHICLE; SECOND RELIABILITY MODEL, by R. L. Ragot and R. L. Hamilton
March 1966. 47 pp.
Figs. UNCLASSIFIED

1. DSRV - Reliability Pred.
2. Deep Submerge. - Rescue Veh - Reliab. Pred.
3. Rescue Veh
I. Hamilton, R.L.
II. Ragot, R. L.
III. Title

A second reliability model of the Deep Submergence Rescue Vehicle (DSRV) is defined. On (over)

UNCLASSIFIED

the basis of this model, a prediction is made of the DSRV reliability for a typical rescue mission. The predicted reliability is computed to be 29%, for a 26-hour vehicle-operating time. The major factor contributing to the low predicted reliability of the vehicle is the high failure rate assumed for the forward and skirt (exterior) lamps. A two-orders-of-magnitude decrease in the assumed failure rate for these underwater lamps results in a predicted reliability of about 80%. Recommendations are made for improving future DSRV reliability studies.