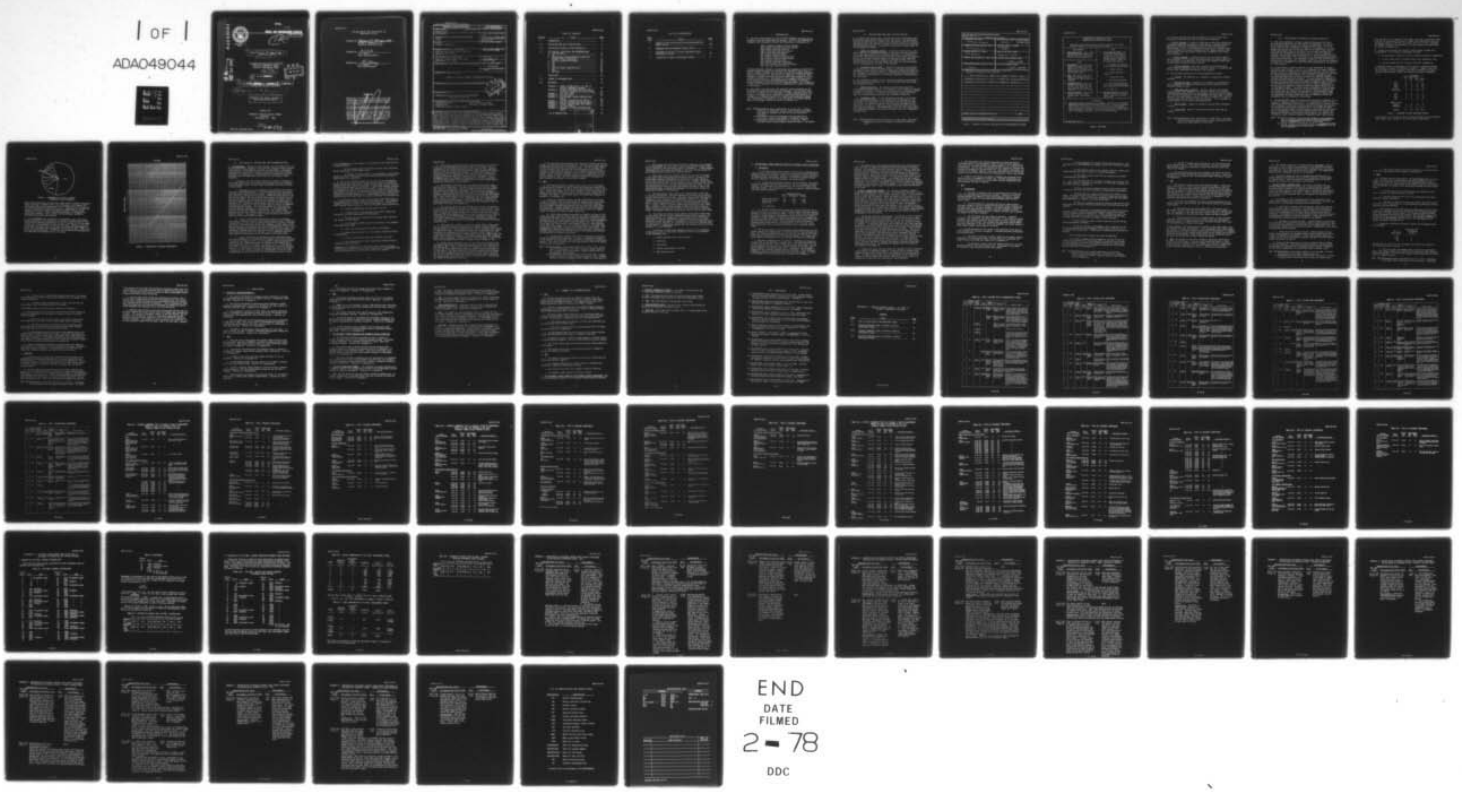
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Prepared for

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AIR-5372
Washington, D.C. 20361

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EVALUATION OF THE CVN 68/CVN 69 LAUNCHING SYSTEM

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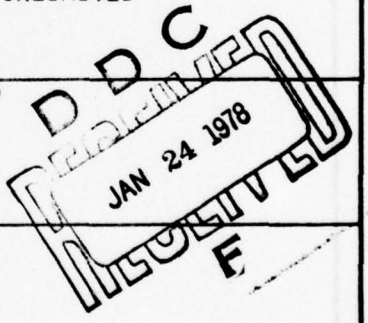
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Shipboard catapult
Steam catapult
Integrated catapult control station
Rotary retraction engine
Flush-deck nose-gear launch

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents the final evaluation of the Integrated Catapult Control Station and associated catapult equipment for the CVN 68/CVN 69 launching system. Evaluation testing was conducted on the TC13 Mod 1 catapult site. The report delineates the deficiencies and discrepancies found in the CVN 68/CVN 69 launching system. Implementation of the recommended changes to the deficient items would greatly improve operations and increase the reliability and maintainability of the catapults aboard the CVN 68/CVN 69 and later carriers with these innovations incorporated.

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I. INTRODUCTION

A. The CVN 68 (USS NIMITZ) and CVN 69 (USS EISENHOWER) launching system consists of many new subsystems and hardware. Each of the following new components were discussed in detail and illustrated in reference (a):

ICCS *(integrated catapult control station)*
MADIS *(manual aircraft data input system)*
CRS *(central recording station)*
FDNGL *(flush-deck nose-gear launch)*
RRE *(rotary-retraction engine)*
CCP *(central charging panel)*
CJB *(central electrical junction box)*
CRO *(constant runout)* bridle arrester
CSV *(capacity selector valve)*
DESI *(digital end-speed indicator)*
Auto JBD *(automatic jet blast deflector)*
LLLV *(low-loss launching valve)*

The above equipment underwent an evaluation test program on the TC13 Mod 1 catapult during the period of 16 August 1970 through 31 March 1976, in order to predict problems with them and to verify the minimum reliability indices of reference (b). Because of the complexity of the Mark 2 NGL equipment, a separate hardware evaluation report was prepared and is presented in reference (c). Information on all equipment failures during this period was collected and comprehensively tabulated to provide a formal assessment of the CVN 68/CVN 69 launching system. The reliability of each of the subsystems and subsystem components as a group is presented in this report.

B. This report also delineates the component failure histories of the CVN 68/CVN 69 subsystems and associated equipment. The principle objectives are to predict the life expectancy of these components and/or subsystems; to recommend those components or subsystems that should be investigated or redesigned based on the 10,000-cycle evaluation program; and to determine the reliability of the CVN 68/CVN 69 launching system based on the design criteria set forth in reference (b).

Ref: (a) NAVAIRTESTFAC Report NATF-EN-1117 of 22 Dec 1971: Initial Evaluation of Integrated Catapult Control Station and Associated Catapult Equipment for the CVN 68 (Interim Report) AD 890273L
(b) NAVAIRSYSCOM Technical Development Plan TDP WW45-24X of 1 Apr 1971: Advanced Development of Shipboard Catapults
(c) NAVAIRTESTFAC Report NATF-EN-1139 of 5 Aug 1976: Mark 2 Nose-Gear-Launch System Hardware Evaluation Report. AD A029020

II. DEFINITIONS AND DATA CLASSIFICATION

A. To analyze the failure data, a method called the "Development Stage Reliability Growth Model" (reference (d)) was chosen. The reliability data was obtained for this analysis from test-site reliability and maintainability forms (see Figure 1 on pages 5 and 6) filled in by operating and maintenance personnel. Failures were classified as being either of the following two classes:

1. RANDOM (OR INHERENT) FAILURE: A failure of this nature is one which occurs at an unpredictable point in time and cannot be attributed to a known design deficiency or marginal performance. A possibility exists that this failure will reoccur because it is service-life related. Because the catapult launching system is comprised of many components and subsystems, each of which exhibits a different service life, the failure pattern is more or less random, and there is no human permanent cure for the failure at the time of the incident.

2. ASSIGNABLE CAUSE FAILURE: A failure of this form is one which is experienced as a result of known design or performance deficiencies, and usually occurs while the system or subsystem is being developed, but the deficiency is corrected prior to certifying the system for service use. Normally, the failure of a particular component or subsystem will not occur again.

B. The reliability analysis of this report was conducted in accordance with the policies of reference (b). The calculations were made using the following policies:

1. MISSION CAPABILITY: The maximum estimated mass launch for four catapults aboard a carrier is 80 aircraft. Each catapult is required to launch as many as 20 aircraft in a single mission at a maximum launch interval of 45 seconds. For reliability analysis, calculations were made for a single-launch capability and a 20-launch capability.

2. CONFIDENCE LIMIT: For the reliability analysis, a 90 percent confidence limit was chosen. This implies that in the long run, the true value of the parameter will be included in the interval 90 times out of 100. It should be noted the TDP *(Technical Development Plan)* (reference (b)) does not stipulate at which confidence level the reliability must be measured. The NAVAIRENGCEN *(Naval Air Engineering Center)* Test Department assigned a 90 percent confidence limit as a reasonable expected value.

Ref: (d) NAVAIRTESTFAC Report NATF-COS-3 of 22 Dec 1972: Analytical Techniques for Cyclical Equipment Exhibiting Reliability Growth

TEST SITE RELIABILITY AND MAINTAINABILITY REPORT
4ND NATF 4850/5 (12-71)
(Instructions on reverse)

1. SITE AND/OR GEAR (4000) TC13 Mod 1 Catapult	6. SITE EVENT NO. (3200)* 18292 7. DATE (3200)* 23 Sep 1970
2. AUTHORIZING ENGINEER AND CODE (4000) M. Manganello	8. COMPONENT EVENT NO. (3200)* (if applicable) Same
3. PROJECT DIRECTIVE NO. (4000)* 2-2-70 G133	9. TYPE OF TEST EVENT (3200)* Deadload Launch
4. FRMR NO. AND JOB ORDER NO. (4000/3201)	10. ELAPSED TIME FOR REPAIR (3201) 2.0 HOURS
5. PART IDENTIFICATION (4000/3200/3201)* C95626	11. MAN-HOURS EXPENDED (3201) 0.5 MAN-HOURS

12. DESCRIPTION OF CHANGE, FAILURE OR REPAIR ACTION (3201/3200)
(include all part numbers of parts replaced)

The maneuver forward solenoid (EF) was replaced because it was chattering causing erratic operation of the maneuver forward valve.

SIGNATURE AND CODE OF SUPERVISOR/SITE OFFICER | DATE

* Indicates initials of recorder required.

FIGURE 1 - EXAMPLE OF TEST-SITE RELIABILITY AND MAINTAINABILITY REPORT

INSTRUCTIONS FOR PREPARING TEST SITE
RELIABILITY AND MAINTAINABILITY REPORT

Code numbers in parentheses indicate group(s) responsible for filling in block. Blocks 1, 2, 3 and 4 are self-explanatory.

4001/3200/3201

5. PART IDENTIFICATION. 4120 or 3200 will provide major component name and P/N. 3201 will give detailed P/N of failed and damaged parts.

3200

6. SITE EVENT NO. Site event number during which a failure occurred. Repairs or replacement work performed after a test event regardless of length of time are to use the last event number.

7. DATE. Date of test event that failure of component occurred or replacement for other reasons was initiated.

8. COMPONENT EVENT NO. Use if individual cycle records are kept for such items as JBD, B/A, NGL, etc., that may be different and independent of site event number.

9. TYPE OF TEST EVENT. Specify type of event, that is, aircraft, bridle no-load, cycle deadload, etc.

3201

10. ELAPSED TIME FOR REPAIR. This is the total time in hours (and parts of hours) that the equipment is out of operation undergoing repair because of a specific failure incident. Do not include such items as:

a. Administrative downtime (awaiting higher-level decisions)

b. Inclement weather

c. Decision made not to operate

d. Time getting tools

e. Time getting materials

f. Time used for preventive and routine maintenance actions done concurrently with the repair

g. Lunch, etc.

11. MAN-HOURS EXPENDED. Record the man-hours expended for the given repair, replacement or maintenance action.

(3201/3200)

12. DESCRIPTION OF CHANGE, FAILURE OR REPAIR ACTION. A description of the failure with names and part numbers of components that failed. If numerous components failed during a single event or required replacement, list each component. Identify corrective maintenance actions which are repairs necessitated by failure of components or subsystems. List the mode of failure if it can be determined. List possible corrective action or recommended redesign.

4ND NATF 4850/5 (12-71)

FIGURE 1 CONTINUED

C. Using the policies set forth in reference (e), the failure data tables were classified into the following three categories:

1. TYPE I FAILURE: A failure of this type is one which prevents the launching system from successfully accomplishing its mission unless an appropriate corrective maintenance action is taken and completed in three minutes or less. If operations must stop to fix or repair a particular component or catapult subsystem and the repairs take more than three minutes, then this type of failure was considered in the reliability analysis.

2. TYPE II FAILURE: A failure of this type is of such a nature that operations of the catapult launching system can continue safely until the mission is accomplished, after which the necessary repair must be made before executing the next mission.

3. TYPE III FAILURE: This type of failure is one which can be safely deferred indefinitely and the necessary repair is included as part of the normal maintenance procedures of the catapult.

D. The following definitions are used throughout this report:

1. FAILURE: The inability of a component to perform its required function.

2. RELIABILITY INDEX: Reliability is defined as the probability that a component will operate properly under given conditions for a specified length of time.

3. MTTR *(MEAN TIME TO REPAIR)*: Should a failure occur during a launch sequence, the components or subsystems making up the catapult launching system should take, on the average, one hour or less to repair. The criterion established by the NAVAIRENGCEN Test Department is that 84 percent of all maintenance actions as a result of Types I, II, and III failures shall have an MTTR of less than one hour. It is a measure of maintainability for the entire launching system.

4. REPAIR EFFORT: Number of man-hours actually spent repairing a failure.

5. REPAIR TIME: Number of hours actually spent repairing the failure.

Ref: (e) NAVAIRTESTFAC Report NATF-E-1074 of 18 Mar 1965: The Applicability of *Certain Distributions to Ship Installations* Reliability and Maintainability Evaluations

III. CVN 68/CVN 69 CATAPULT SYSTEM RELIABILITY

A. Table AI of Appendix A presents a detailed listing of all Type I failures experienced with the CVN 68/CVN 69 configuration on the TC13 Mod 1 catapult from 16 August 1970 through 31 March 1976. The reliability data for this is presented in Table BII of Appendix B. To test whether the failure rate in the first half of the service-life test differed significantly from the second half of the test, procedure 6 of reference (f) was applied to the failure data in Table AI, Appendix A. From the first analysis shown in Appendix B, it can be asserted that the component failure rate of the first half of the evaluation period exceeded that of the second half. The reliability results for the CVN 68/CVN 69 configuration, including all "assignable-cause" type failures are presented in Table BII of Appendix B for the first and second halves of the service-life test period.

B. Of the 64 Type I failures reported, 35 were classified as "assignable-cause" type failures. That is, if a component or catapult subsystem failed a number of times before an improvement was made, only the first failure was used in computing the system reliability (Table BIII, Appendix B). Those failures which followed were considered "assignable-cause" type failures which would not have occurred if an improved component or catapult subsystem had been installed. A second reliability analysis of this failure data assumed that these design improvements were implemented. Because the failure rate exhibited during the component service life 0 to 3113 differed from the service life 3113 to 11058, a subdivision in service life was necessary to assure reliability growth within each of the development stages. The Barlow-Scheuer Reliability Growth Procedure of reference (g) was then used for the second reliability analysis and the failure data was combined and presented in two development stages. The reliability results shown in Table BVI of Appendix B clearly show the improvement in system reliability when the repeated failures are eliminated from the reliability calculations.

C. The desired MCBF *(mean cycle before failure)* given in reference (b) as a goal for catapult systems at the end of a service-life period is 405, assuming an exponential distribution. The assumption of a constant failure rate is usually a conservative starting point for mathematical analysis. The reliability growth model procedure used in this report provides a far more accurate method of determining the actual MCBF for the CVN 68/CVN 69 configuration, because Design Changes and Service Changes which improve the system are continually being installed. For example, the reliability results without repeating "assignable-cause" type failures

Ref: (f) Epstein, Benjamin, Tests for the Validity of the Assumption that the Underlying Distribution of Life is Exponential, Part I, TECHNOMETRICS, Vol. 2, No. 1, Feb 1960.
(g) Barlow, Richard E. and Scheuer, Ernest M., Reliability Growth During a Development Testing Program, TECHNOMETRICS, Vol. 8, No. 1, Feb 1966.

shown in Table BVI of Appendix B is an MCBF of 243 and a reliability index of 0.921 for the service life 3113 to 11058, while the MCBF is 164 and a reliability index of 0.885 for the service life of 0 to 3113. Although the system reliability is improving, it is still below the desired value set forth in reference (b).

D. During the evaluation test period, 11,058 catapult launches were accomplished. Of the catapult launchings conducted:

1. 64 were termed "critical" or Type I failures (Table AII, Appendix A),

2. 67 were termed Type II failures (Table AIII, Appendix A), and

3. 132 were termed Type III failures (Table AIV, Appendix A).

A breakdown by major subassemblies of the number of component failures and the type of failure is presented in Figure 2. Figure 2 also indicates the RRE as being the biggest contributor followed by the Mark 4 and CRO bridle-arrester, FDNGL, and vertical-accumulator assemblies.

	Failures			
	Type I	Type II	Type III	Total
ICCS	3	9	0	12
RRE	38	4	14	56
FDNGL	9	0	41	50
LLLV	4	1	3	8
VERT ACCUM	6	12	25	43
CJB	1	0	1	2
CCP	0	8	9	17
DESI	3	3	0	6
CSV	0	6	8	14
MARK 4 & CRO BRIDLE ARRESTER	0	24	31	55
TOTALS	64	67	132	263

FIGURE 2 - COMPONENT FAILURE BREAKDOWN HISTORY

With respect to "critical" or Type I failures, Figure 3 on the following page clearly shows the RRE as the single largest contributor.

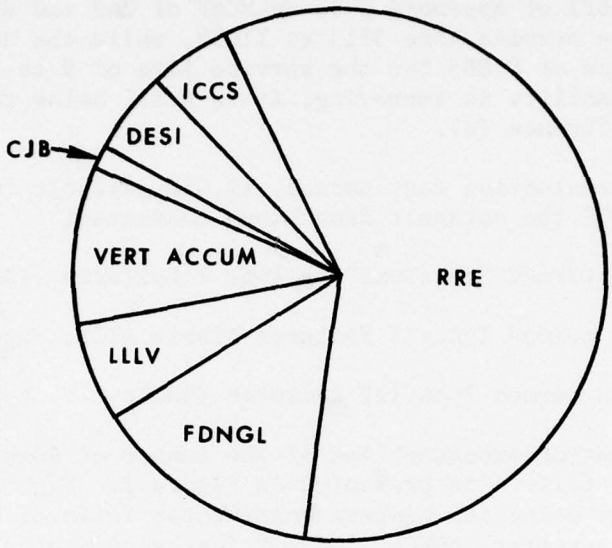


FIGURE 3 - BREAKDOWN OF 64 TYPE I FAILURES ACCORDING TO EACH SUBSYSTEM

Based on the failure data of Table BIII (data without repeated "assignable-cause" failures) of Appendix B for the 10,000-cycle test program, the reliability index of the system based on a confidence level of 90 percent and a 20-launch mission capability is 0.921. Improvement to the RRE components is required to attain the minimum acceptable overall system reliability of 0.952. Without related RRE failures, a reliability of 0.954 can be obtained. Also, without the RRE failures, an MCBF of 4058/26=425 would have been obtained.

E. The NAVAIRENGCEN Test Department has established that the maintainability, expressed as the probability of repair in a given time, for the CVN 68/CVN 69 launching system shall be that 84 percent of all the repair actions will be accomplished in less than one hour. Figure 4 on the following page illustrates that of the 263 total corrective maintenance actions, only 50 percent were accomplished in one hour or less. This is far below the established goal. The MTTR of the CVN 68/CVN 69 launching system components was determined to be 3.05 hours.

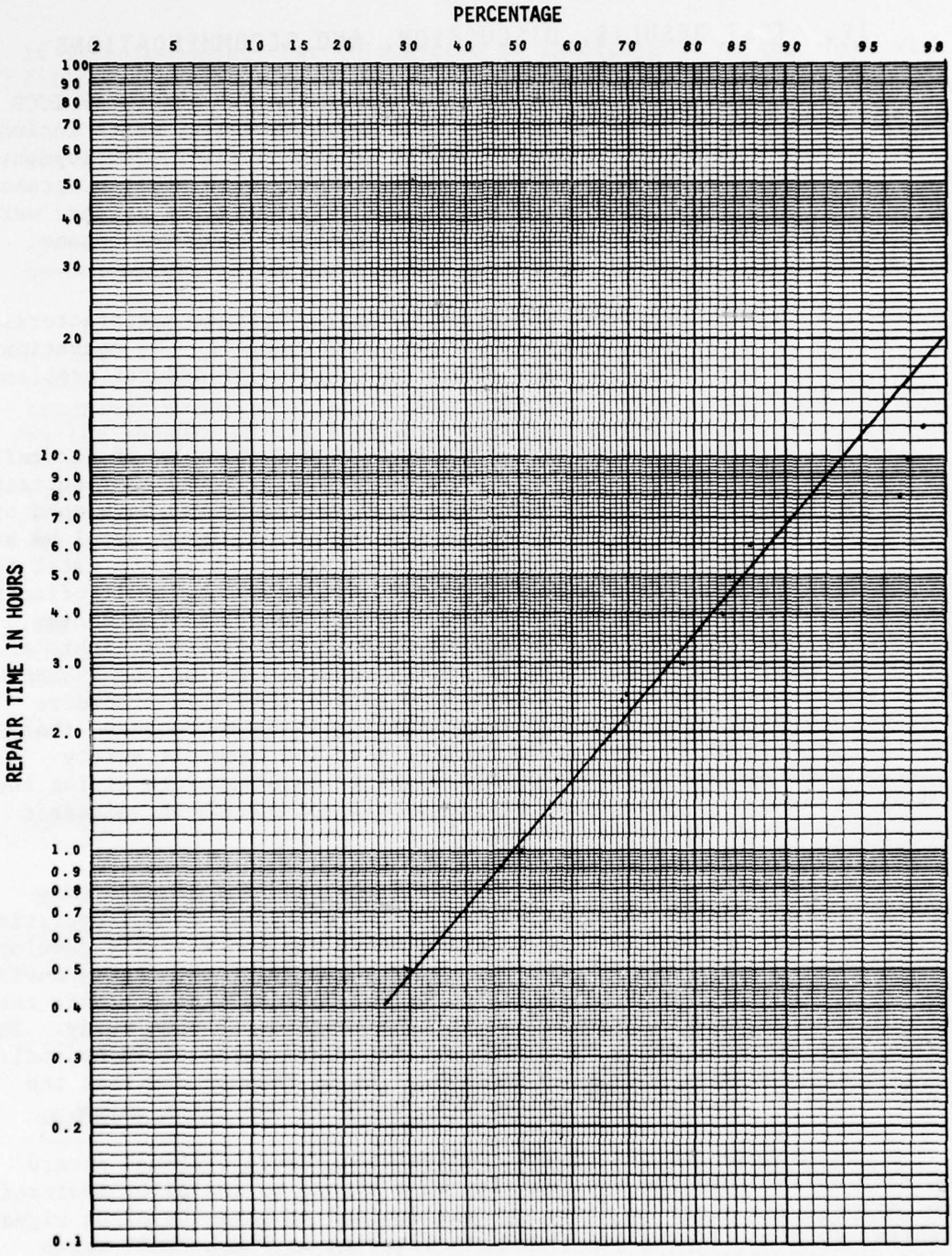


FIGURE 4 - PROBABILITY OF REPAIR (PERCENTAGE)

IV. TEST RESULTS, DISCUSSION, AND RECOMMENDATIONS

A. ICCS AND MADIS: During the report period, the CVN 68/CVN 69 ICCS system was used for all programs on the TC13 Mod 1 catapult, which included 1,058 aircraft, 3,050 deadload, and 6,944 no-load events. Development and evaluation testing were conducted concurrently with other programs throughout the report period. Deficiencies were corrected as they were found and Service Changes installed as material and manpower became available.

1. In general, the ICCS system continued to operate satisfactorily. The testing during this report period was concerned with the operation of the equipment except for three minor operational procedural problems detailed below:

a. The pilot salute was replaced by the turning on of aircraft lights as a PILOT READY signal. It was subsequently found that certain sun conditions could obscure this signal. A procedure was developed by which the safety observer would not give a THUMBS UP signal until he saw the aircraft lights, and the catapult officer would not launch until he saw this GO signal. The procedure was used during two catapult officer and crew training periods at the Naval Air Technical Training Center, Lakehurst, N.J. During the second period, both the aircraft lights and the hand salute were used, with the safety observer giving the THUMBS UP after seeing both signals. All concerned agreed that this procedure provides adequate redundancy for this signal. It is recommended that the ICCS procedures be amended to require that the catapult safety observer must see the aircraft lights or pilot salute before giving the THUMBS UP signal. The catapult officer shall not launch the aircraft until he receives the THUMBS UP signal.

b. Initial ICCS testing indicated the need for an auxiliary deck panel to indicate catapult status during emergency mode I operations. A panel similar to that used on existing ships was successfully developed and tested. One unresolved problem, the visibility of the lights during daytime operations, is being corrected by the NAVAIRENGCEN SI *(Ship Installations)* Engineering Department and will be checked out when ready. The development problems which have been corrected are detailed in Appendix C (discrepancy reports TC13-1-127 and 164). It is recommended that the final system be incorporated on the CVN 68/CVN 69 and later ships.

c. Before the CVN 68 was commissioned, Navy personnel aboard the ship established the desirability of a signal to the pilot indicating the catapult was about to fire. It was decided to have the pilot signal light(s) go from illuminated steady to flashing at FINAL READY which would signal the pilot the catapult was about to fire. The system was successfully tested and, in general, was favorably received by personnel involved. It was pointed out that the flashing light not only provided a signal that the catapult sequence was progressing to FIRE, but also acknowledged that the catapult officer had received the pilot's salute.

It is recommended that this system be incorporated on the ships with the following provisos:

(1) The system should be modified to insure that operations are not interrupted if the flasher fails.

(2) Because this system adds to the complexity of the control system, the ship's forces should conclusively agree that the change is needed before it is installed.

2. The "final" shipboard MADIS was installed at the NAVAIRENGCEN. During initial checkout, several components were found to be defective. Numerous parts were replaced but because of continuing failures the system never became completely operational. Repairs were severely hindered by the absence of spare printed circuit boards. After the CVN 68 units were removed, all work on the system was stopped because of reliability problems and the need for some type of detection system to insure correct information is being transmitted. The NAVAIRENGCEN system has been updated and will be tested before the system is returned for shipboard use.

3. During the initial testing, several deficiencies were noted in the catapult control system (reported in reference (a)). The following changes provided by C13 Mod 1 Catapult Design Change No. 250 and C13 Mod 1 Catapult Service Change No. 209 have corrected these deficiencies:

a. A remote SUSPEND light was provided at the CCP.

b. A complete set of "malfunction" and "status" lights were provided at the CCP during normal ICCS operations.

c. The CSV set switch interlocks the command signal with the CSV readout at FINAL READY.

d. A hot CATAPULT SUSPEND switch was provided at the emergency deck-edge control panel.

e. One of two steam-pressure switches was eliminated.

f. Steam pressure switch is in the catapult interlock circuit at FINAL READY.

g. A "dry" cycle bypass switch was provided at the CCP.

h. The steam pressure GO NO-GO lights were removed from the catapult officer's console.

Inasmuch as the changes made to the reported deficiences have been satisfactorily tested on the TC13 Mod 1 catapult, it is recommended that they be incorporated on the CVN 68/CVN 69 and later vessels.

4. Four console status-light diode capsules failed after a life of 2,200 to 6,300 launchings and periods of one to four years. This is considered to be a satisfactory service life range for this component. However, three of the four failures shorted to the PUSH-TO-TEST circuit, causing all console indicators to light. Although this seems to be a minor problem, it did incapacitate the consoles until the problem was isolated; therefore, these were counted as Type I failures. It is recommended that this problem be investigated in an effort to prevent the diode capsule failure from incapacitating the entire console and to improve the reliability of the catapult.

5. As reported in reference (a), the console-switch-cover hinge pins slid out of position. This was successfully corrected by crimping the ends of the hinge pins. The cover hinges continue to fail because their rotation is limited to 90 degrees. One cover on the catapult officer's console FIRE push button was modified to allow 180 degrees of movement; this permitted the switch cover to lay back against the console face. This cover has been in use successfully for over 2,500 launchings over a period of 15 months. It is recommended that the console-switch-cover specifications be changed to provide 180 degrees of movement to prevent overstressing the hinges. This problem was reported by discrepancy report TC13-1-167 (see Appendix C).

6. The original mechanical deck SUSPEND light flasher was replaced by a solid-state flasher in an effort to improve the service life. Three failures of the solid-state flasher have occurred on the TC13 Mod 1 catapult. Although the average service life of about 1,200 hours is an improvement over the mechanical flasher, it does not approach the 5,000-hour life predicted by the manufacturer. The only explanation is that the solid-state flashers at the NAVAIRENGCEN were occasionally allowed to run longer than the manufacturer's recommended 16-hour-maximum continuous operating time.

7. A problem with corrosion of the pilot signal light's lamp socket was successfully corrected by installing a corrosion resistant socket. The new sockets were in good condition after 7,100 launchings over a period of almost four years. The shipboard sockets will be replaced on an attrition basis in accordance with C13 Mod 1 Catapult Service Change No. 207. An additional problem with water leaking around the pilot signal light lens gasket was corrected by providing a new molded gasket which was installed with a sealant compound. These gaskets have been installed on the CVN 68/CVN 69 in accordance with C13 Mod 1 Catapult Service Change No. 256.

8. During initial shipboard tests, it was found that the Mark 2 NGL deck READY light being lit during nonoperating periods was objectional on the darkened deck. The only provision for turning off this light was to shut off the main catapult power which is needed to keep the catapult in a ready status. This was corrected by C13 Mod 1 Catapult Service Change No. 231 which changes the bridle-arrester/NGL selector switch wiring to shut off the deck READY light when the bridle-arrester mode is selected. The wiring change was successfully tested on the TC13 Mod 1 catapult and the change was installed on the ship.

9. Two additional minor problems were corrected by Design and Service Changes and have been reported separately. The ICCS console desk tops had insufficient clearance for the operator's legs. C13 Mod 1 Design Change No. 251 provided a new thin desk top which successfully corrected the problem as reported by reference (h). The telephone selector switch and telephone jacks originally supplied with the ICCS consoles were not required. Except for minor problems, these parts were removed by C13 Mod 1 Service Change No. 182. The minor problems, reported by reference (i), were corrected by Revision A to the Service Change.

B. RRE

1. The desired individual catapult cycle time of 35 to 45 seconds as delineated in reference (b) still cannot be attained as initially reported in reference (a): the RRE is the biggest deterrent to this attainment. Unless the catapult cycle time is relaxed, the SI Engineering Department must improve the cycle time of the RRE in order to meet the TDP (reference (b)) goal. A discrepancy report was issued and presented in Appendix A of reference (a).

2. During the evaluation period, the RRE contributed 38 "critical" or Type I failures to the overall system--the biggest contributor being the bridle-tensioner solenoid which failed on 12 different occasions. The next biggest contributing component was the grab latch which failed on 8 occasions. Improved design on the solenoid and better operating procedures while cycling the RRE would reduce the failure rate significantly and improve the overall system reliability.

a. Efforts are presently being made to minimize failures of the bridle tensioner, maneuver forward and aft, and retract and advance valve solenoids by imposing a strict preventative maintenance program on these solenoid valves. The pilot section of these valves are being disassembled and inspected monthly for possible spool bindings, rust, and corrosion. At the same time, the voltage to the solenoid valves is being monitored for possible low voltage. If a low voltage is detected, a voltage transformer will be installed to prevent the solenoid from overheating. The NAVAIRENGCEN SI Engineering Department is also conducting a parallel development program with an oil-filled solenoid valve which would minimize the possibility of solenoid overheating.

b. The grab-latch failures are strictly attributed to operating procedure during no-load launchings. The grab is prematurely attached to the catapult shuttle during a no-load launch, resulting in a grab-latch failure. This type of failure was never experienced on the CVN 68 during the first year of operation.

Ref: (h) NAVAIRTESTFAC Letter Report NATF-L172 of 15 Oct 1973: Installation and evaluation of C13 Mod 1 Catapult Design Change No. 251: Catapult officer and monitor console writing tops; installation of (Final Report)

(i) NAVAIRTESTFAC Letter Report NATF-L179 of 20 Mar 1974: Installation of C13 Mod 1 Catapult Service Change No. 182: Telephone selector switch and telephone jacks; removal of (Final Report)

3. The catapult FULL-AFT limit switch also continues to be a problem at the NAVAIRENGCEN and in the Fleet, causing considerable catapult downtime as reported in the discrepancy report of Appendix D. A newly designed vulcanized plug would solve the problem of the wires rotating within the plug connection and touching other wiring contacts.

4. Minor Type II and III failures (Tables AIII and AIV of Appendix A) were also experienced during the evaluation period. O-rings of the various RRE components contributed to the majority of these failures. Of the minor failures experienced, the drum anchor assembly caused problems on various occasions. In each instance either the drum anchor clevis, the quick-release pin, or the drum anchor subassembly was bent. An improved design would reduce catapult maintenance and make it easier for operating personnel to engage and disengage the drum anchor during preoperational checkout of the catapult.

5. The RRE hydraulic motor failed after approximately 18,000 RRE cycles were accumulated. The Fleet experienced the same type of failure and poor history with four motors. The motor radial thrust bearings disintegrated in all instances. The manufacturer (Vickers Co.) has redesigned the bearing group assembly and is installing it in the failed motors. One of these motors is on test at the NAVAIRENGCEN Test Department. Parallel efforts by the SI Engineering Department are also being made to install a motor purging system to remove the fluid around the radial and thrust bearings and circulate the fluid through a filtering system. Development tests are continuing on the TC13 and TC13 Mod 1 RREs.

6. The advance and retract large operator directional valves which utilize larger control orifices performed satisfactorily throughout the evaluation period. No clogging of the directional valve orifices was experienced. However, the orifices clogged during initial sea trials aboard the CVN 68 (USS NIMITZ). Subsequently, a service change was issued to install piping strainers at the orifices to protect the orifices from foreign matter. A development program with the filtered orifices is being conducted at the NAVAIRENGCEN.

7. In general, the RRE system hardware service life is considered satisfactory; however, additional development efforts are recommended on the following items:

a. Bridle-tensioner pilot valve solenoid

b. Grab latch

c. Drum anchor

d. Catapult performance cycle time

e. RRE hydraulic motor

C. CRO AND MARK 4 BRIDLE-ARRESTER SYSTEM WITH AUTOMATIC BRIDLE RETRACTION

1. BACKGROUND

a. The CRO bridle-arrester-engine control system, combined with a remote readout runout indicator system and an automatic bridle-retraction deflector system, can provide a means of increasing the overall efficiency of bridle-aircraft operations. Reference (a) reported limited success with all components of the CRO/automatic retraction system.

b. A prototype CRO bridle arrester, runout indicator, and bridle-retraction deflector were installed first on the TC13 catapult to begin testing. All components were transferred to the TC13 Mod 1 catapult for continued testing. The following is a summary of catapult events conducted with the various subsystems:

	Catapult Events		
	TC13	TC13 Mod 1	Totals
CRO Bridle Arrester	709	1,954	2,663
Runout Indicator	238	981	1,219
Deflectors	*	337	337

* No operation.

c. The CRO bridle-arrester system was tested through the end of 1972, and proved to be unable to support normal catapult aircraft programs because of a limited performance range. The CRO engine was converted back to a Mark 4 bridle-arrester configuration during an early 1973 catapult downtime. The NAVAIRENGCEN SI Engineering Department has redesigned much of the CRO system, such as the brake cam contour, brake valve, brake pump, and electrical control system. The redesigned CRO bridle-arrester is presently being installed at a second location on the TC13 Mod 1 site. This installation will be tested and reported on as a possible service change.

2. The runout indicator system operated intermittently until the CRO bridle arrester was changed back to a standard Mark 4 bridle-arrester engine. The indicator START switch and its actuator cam could not be easily mounted on the standard Mark 4 bridle-arrester engine. The runout indicator program was postponed until an operating CRO system is available.

3. The new, strengthened set of deflector assemblies was installed in April 1972 on the TC13 Mod 1 catapult site. The deflectors were used for 317 bridle-retraction events during the current test period. The deflector linkages and bearings were overhauled twice during that time to repair damaged or excessively worn parts. Apparently, the increased strength of the actuating linkages was not sufficient. These deflector assemblies cannot be considered satisfactory for Fleet usage. A series of discrepancy reports was issued and is presented in Appendix E.

4. The deflectors, when working satisfactorily for a brief period of time, were used to conduct an automatic bridle and catapult retraction program. The automatic bridle and catapult retraction mode of operation was used for approximately 75 bridle no-load events: 60 events were complete successes. The deflectors caused problems during 13 events; and problems with the electrical circuit control for initiating automatic retraction caused 2 unsuccessful events. An appropriate electrical circuit change corrected the latter problem. The automatic bridle and catapult retraction mode of operation is considered an improved method of catapult operations. The lack of an acceptable bridle deflector curtailed continued evaluation of the automatic retraction program. The deflector test program has been postponed until a need for automatic bridle retraction develops in the Fleet.

D. VERTICAL ACCUMULATOR ASSEMBLY: The vertical accumulator consists mainly of a cylinder and a free piston. The accumulator maintains a relatively constant pressure in the catapult hydraulic system. As the hydraulic fluid is used, the air pressure causes the piston to move toward the top (fluid end) of the accumulator. When the piston moves toward the top of the accumulator, the lever-operated stroke control actuates a switch which causes the main hydraulic pumps to go on stroke; as the piston nears the bottom of the accumulator, the stroke-control actuator rod engages a switch which stops the main pumps from pumping. Also located at the top of the accumulator is a volume-normal actuator which operates the hydraulic-accumulator volume limit switch. When actuated, this switch breaks CATAPULT INTERLOCK and prevents firing of the catapult until sufficient fluid is replenished in the accumulator.

1. During the evaluation test period, 6 "critical" or Type I failures (Table AII, Appendix A) were experienced. Three of these failures were attributed to the stroke-control actuator rod. On one occasion, the rod was broken when a piping connector was left inside the accumulator after an overhaul. In the other instances, the rod was bent and caused improper operation of the ON-OFF STROKE limit switch, and the rod was stuck because of rust and corrosion built up between the rod and gland. These failures could have been averted by improved maintenance procedures. That is, an inspection of the accumulator would have disclosed the piping connector left in the accumulator, and bleeding the water condensate from the air side of the accumulator would have prevented the rust and corrosion buildup. Two Type I failures of the limit switch occurred; these failures were strictly service-life related and could not have been prevented. The failure of the volume-normal actuator assembly was the last of the Type I failures, and again, improved maintenance procedures could have prevented this failure. The assembly was damaged when the piping was left inside the accumulator.

2. Twenty-four minor failures (Table AIV, Appendix A) were attributed to the vertical accumulator assembly. A majority of the failures were leaking O-rings on the stroke-control and volume-normal actuator assemblies. The most serious repair was the replacement of the vertical accumulator cylinder because the interior wall was seriously scored and allowed air to leak into the fluid side of the accumulator.

3. One discrepancy was reported (Appendix F) during the entire evaluation period: the accumulator piston O-rings (3) were replaced because they had stretched excessively, approximately 3 to 7 inches on the circumference. At the time, the problem was not considered a serious one because the O-rings had been installed for 7,416 catapult launchings over a period of 39 months. However, since then this same type of failure was reported from the Fleet and efforts are being made to correct the problem.

4. Overall, the vertical accumulator assembly has performed satisfactorily and is recommended for Fleet use, providing improvements are made to the stroke-control and volume-normal actuator assemblies which would minimize the Type I failures.

E. CSV

1. DESCRIPTION

a. The CSV, in parallel with the launching-valve metering rod, forms the launching-valve opening rate control. Variation of the CSV setting programs the degree of rotary launching-valve motion, thereby controlling the amount of steam used which provides proper aircraft launch energy.

b. The electronically controlled CSV has two remote control locations (catapult officer's console and deck-edge control station) and a manual control at the valve assembly. The valve setting is monitored electronically simultaneously at three locations (catapult officer's console, or deck-edge console monitor's console, and CCP) plus a mechanical readout at the valve assembly.

c. The CSV system has four modes of operation: automatic (primary), jog, handwheel, and defeat interlock. In all modes but defeat interlock, the catapult cannot be fired unless the actual setting agrees with the requested setting. The automatic and jog modes provide remote electronic operation of the CSV, while the handwheel and defeat interlock modes require manual positioning of the valve.

2. The CSV was used for all events in the reporting period and provided satisfactory operation throughout. Problems which were encountered are detailed below:

a. Four Type II failures occurred, which did not reduce catapult readiness to an unacceptable level, but did result in a subsystem component failure as follows (see Table AIII of Appendix A):

(1) The motor control relay was replaced once due to an inadvertent overload on the relay control coil. Replacement of the relay and removal of the overload corrected the problem.

(2) The mechanical CSV counter failed and was replaced. This was reported via NAVAIRTESTFAC discrepancy report TC13-1-129 (see Appendix G).

(3) The hundreds digit of the catapult officer's command unit failed and was replaced as a matter of routine maintenance.

(4) The shaft encoder failed and was replaced per standard troubleshooting procedures.

b. The following Type III failures occurred; these failures did not reduce catapult readiness but did result in individual component failures (see Table AIV, Appendix A):

(1) Three electronics package printed circuit boards failed on separate occasions and were replaced per troubleshooting procedures.

(2) Three position readout digits failed on different occasions. One digit failed at the monitor's control console and two digits failed at the CCP. These failures are considered normal and replacement was accomplished as a matter of routine maintenance.

(3) The valve assembly stem which translates gear-train rotary motion into CSV spindle positioning linear motion was found worn and was replaced.

(4) Two instances of corroded electrical contacts were noted: CSV mode selector switch and transmit/comparator contacts in catapult officer's control console command unit. These problems were due to excessively high humidity in the ICCS after airconditioner malfunctions. Cleaning the contacts restored the system to full operation.

(5) One hydraulic supply piping O-ring was replaced through normal maintenance procedures.

(6) On one occasion, the handwheel used to manually set the CSV spindle position became disengaged from the gear train due to its retaining ring working loose. Reseating the retaining ring corrected the problem.

3. The following Service Changes have been accomplished:

a. C13 Mod 1 Catapult Service Change No. 234 (EO 75-372) CSV spindle lock; provision of. This Change was incorporated as a result of Fleet problems, to eliminate CSV spindle rotation and related catapult end-speed variation. An installation evaluation of this Service Change is presented in reference (j).

Ref: (j) NAVAIRTESTFAC Letter Report NATF-L212 of 25 Jun 1976: Initial-installation evaluation of C13/C13 Mod 1 Catapult Service Change No. 298/234, Capacity selector valve spindle lock; provision for

b. C13 Mod 1 Catapult Service Change No. 225, CSV instruction plate; installation of. This Change warns that care must be exercised when working on the valve assembly to insure that the CSV "zero" setting is not changed.

4. The CSV system functioned well throughout the reporting period. Problems were handled through normal maintenance procedures. Use of the CSV system will continue with all applicable present and future catapult configurations.

F. CCP

1. The CCP was in service for 11,058 catapult events. During that time, no "critical" or Type I failures could be attributed to the CCP components. The operating personnel consider the CCP a big improvement over the old system, in that all the catapult subsystems can be monitored from one location. In general, the CCP operated satisfactorily during the evaluation test period. Minor failures with the CCP components were experienced and are listed in Tables AIII and AIV of Appendix A. The component deficiencies are reported in Appendix H.

2. Two of the CCP compónents that cause recurring problems are the selector push-type light switches and the isolation valves to the gauges on the panel.

a. The light-selector-switch knobs have a low service life. The failure usually occurs when the knob's indicating arrow segment falls out: the rigidity of the remaining thin plastic cylinder is so weakened that the remainder of the knob soon fails, making the switch useless.

b. The isolation valves to the gauges become so badly corroded internally with rust buildup, that the valves freeze and the handles cannot be turned. In many instances, the operating personnel will break off the handles when trying to turn them.

In both instances, the information was reported to the design agency where the problems are being investigated. It is recommended that a more rugged cover plate or a one-piece selector switch knob be incorporated to eliminate the switch failure, and stainless-steel valves should replace the corrodible valves on the CCP gauges. These deficiencies are not considered serious but their corrections will further improve the system.

G. CJB: The purpose of the CJB is to make an electrical modification or change to the catapult launching system relatively simple to accomplish. Electrical design or service changes can readily be incorporated by running short lengths of wire from one terminal trip to another, instead of running long lengths of wire to a particular junction box.

1. The CJB was in service for 11,058 catapult launchings. Only one "critical" or Type I failure was experienced: the CATAPULT-FIRE relay R28 burned out and catapult operations were terminated until a new relay was installed. Also, only one minor failure occurred: the LAUNCH-VALVE-CLOSE relay R-2 overheated and had to be replaced.

2. Electrical design and service changes were satisfactorily installed during the evaluation test period and entailed a minimum amount of time and labor. This substantiates the initial intent of the CJB; therefore, the concept is acceptable for Fleet use.

H. LOW-LOSS ROTARY LAUNCHING VALVE. The rotary launching valve is a duplex rotary-plug-type valve actuated by a single hydraulic cylinder. The plugs rotate a maximum of 90 degrees during opening and closing. In the full-open position, each plug provides a straight-through minimal press drop flow diameter of 12 inches. Initial testing and evaluation of the prototype rotary launching valve are delineated in references (j), (k), and (l).

1. The shipboard rotary launching valve was in operation for all events conducted during the reporting period. Operation of the valve was satisfactory. The problems encountered are detailed below.

a. Four Type I failures occurred with the clock timer start hydraulic pressure switch, PN 414314-1. The pressure switch remained in the actuated position, rendering the catapult control circuit disabled. In each case, replacement of the faulty switch produced satisfactory operation. Investigation of the problem disclosed that vibrations produced by entrapped air shifted the switch adjustment. Proper venting of the launching valve hydraulic system has corrected the problem.

b. One Type II failure occurred. A grease fitting on the launching valve body ruptured and allowed steam, which is always present in many of the lubrication channels, to escape into the launching valve area. No extraordinary reasons were noted for the failure. Replacement of the failed fitting corrected the problem.

c. Three Type III failures occurred. These failures were hydraulic fluid losses in the launching valve control piping due to failed O-rings, PN AN6230-8(2) and AN6230-5. These failures were considered normal, did not reduce operational readiness, and were corrected through normal maintenance procedures.

2. During the reporting period, C13 Mod 1 Catapult Service Change No. 204 was installed. This Service Change provides an improved method for removing the launching valve hydraulic actuator piston. Evaluation of this Service Change will be accomplished under a separate cover.

Ref: (k) NAVAIRTESTFAC Letter Report NATF-L7 of 16 Jan 1968: Low-loss launch valve (roto-valves); interim report on
(l) NAVAIRTESTFAC Letter Report NATF-L105 of 16 Feb 1971: Low-loss launching valve (roto-valve); final report on inspection of

3. The rotary launching valve will continue to be used and monitored in all applicable future catapult configurations.

I. DESI

1. The DESI system was designed by the NAVAIRTESTCEN *(Naval Air Test Center)* to measure the catapult shuttle end speed immediately after a launch, and to display this end speed and corresponding shot number at various locations. The DESI system was designed to replace the currently used chronograph and provides three important advantages over the chronograph:

a. The DESI provides an instant display and permanent record after a launch in as many locations as desired.

b. The DESI eliminates the use of the chronograph brush which requires frequent replacement.

c. The DESI is automatic and does not require operating personnel (other than to turn power on at the beginning of operations), thereby reducing operating personnel.

2. The evaluation of the DESI system was conducted on the TC13 Mod 1 catapult by comparing the DESI end speed with the chronograph end speed for a total of 2,238 catapult events. The reliability and performance levels determined for the DESI unit indicate that the DESI system is acceptable for Fleet use (see reference (m)). The system has remained in service at the NAVAIRENGCEN and has replaced the chronograph as the primary end-speed recording device.

3. During the 2,238-event evaluation period, the following results were obtained:

No. of DESI Events	Variation From Chronograph (± Kn)
1,965	1
240	2
30	3

The DESI did not record for the remaining three events as a result of the following 3 Type I failures:

a. The stop sensor was damaged when it was hit by the magnetic vane. This damage resulted in a short circuit within the sensor and subsequent malfunction. The sensor was replaced after having been in service for 1,551 catapult events.

Ref: (m) NAVAIRTESTFAC Report NATF-EN-1126 of 10 Jul 1973: Evaluation of the DESI (Digital End-Speed Indicator) System. AD 912079L

b. The stop sensor required replacement again after 1,303 events. A wire between the connector plug and the internal coil had broken at the soldered connection.

c. A similar problem as mentioned in item b occurred with the start sensor, which was replaced after 1,401 events.

A discrepancy report was issued and is presented in Appendix I.

4. The following Type II failures occurred which did not affect the end-speed computation, but did result in failure of one of the three readout stations:

a. The PC *(printed circuit)* board in the printer failed after 6,238 events with the result that the shot number did not increment.

b. The "Data Receiver" and "Decoder Driver" PC boards failed after 6,389 events. This resulted in failure of the remote readouts. The problem was corrected by replacing the PC boards.

5. The polyurethane material that supports the magnetic vane on the catapult shuttle became brittle and cracked. Sufficient deterioration had occurred to require replacement of the magnet after 2,864 events and 14 months of operation. A new magnet assembly with no improved polyurethane material has been installed for 3,447 events and 24 months of operation. This is considered satisfactory for service use.

6. Recent technological advances in microprocessor-type computers have resulted in a redesign of the DESI using this principle, ultimately resulting in higher reliability. Incorporation of the DESI into the Fleet will be delayed pending test results of this new system.

J. AUTO JBD

1. An automatically actuated JBD system has been developed by the NAVAIRENGCEN SI Engineering Department to be used in conjunction with NGL-type aircraft. The basic design concept of the system is to use certain normal catapult functions as signals to an auto-JBD control system to raise and lower the deflector panel at the proper time during the launch sequence.

2. The development and evaluation of the auto-JBD system was conducted for use on the CVN 69 and for retrofit to vessels using the Mark 2 FDNGL units. The principle of operation and the results of the evaluation are presented in reference (n). It was determined that the auto-JBD system is mechanically satisfactory for use on the CVN 68/CVN 69, for use with NGL-type aircraft. Use of the auto-JBD will eliminate the need for

Ref: (n) NAVAIRTESTFAC Report NATF-EN-1130 of 28 Feb 1974: Evaluation of the Automatic JBD (Jet Blast Deflector) System. AD 775665

a JBD operator on the flight deck during NGL operations, while also maintaining catapult cycle times obtained with the manual JBD operation; however, a JBD operator will still be required to man the deck-edge station during bridle-type aircraft operations.

3. The auto-JBD control system was installed on the Mark 4 JBD on the TC13 Mod 1 catapult and was operated successfully for 1,076 cycles. Several system design deficiencies were encountered during the installation checkout and are reported in Appendix J. After correction of these design discrepancies, no electrical or mechanical problems were encountered throughout the evaluation period of 1,076 JBD cycles.

4. Numerous safety features have been incorporated into the JBD system which enhance the overall system safety for flight-deck personnel and aircraft. The concept of automatic control of the JBD, however, was determined to be potentially unsafe for flight-deck operations and was therefore removed from the complement list of CVN 68/CVN 69 associated catapult equipment. The automatic control portion of the electrical system was therefore removed from the Mark 4 JBD on the TC13 Mod 1 catapult.

V. CONCLUSIONS

A. RELIABILITY AND MAINTAINABILITY

1. The overall CVN 68/CVN 69 launching system reliability including all "assignable-cause" failures is an MCBF of 164 and a reliability index of 0.885. *(Section III, Paragraph C)*

2. The overall CVN 68/CVN 69 launching system reliability without repeating "assignable-cause" failures is an MCBF of 243 and a system reliability index of 0.921. *(Section III, Paragraph C)*

3. The reliability criteria of 0.952 using a 90 percent confidence level is attainable by improving the mean life of the CVN 68/CVN 69 subsystems which have demonstrated a poor failure history. *(Section III, Paragraph D)*

4. Only 50 percent of the 263 maintenance actions were accomplished in one hour or less. This is far below the NAVAIRENGCEN-established criterion that 84 percent of the repair actions shall be accomplished in less than one hour. *(Section III, Paragraph E)*

5. The MTTR of the launching system components was 3.05 hours. In order to reduce the time to repair, components having modular design will have to be incorporated. *(Section III, Paragraph E)*

B. ICCS

1. Both the pilot's hand salute and aircraft lights should be used with the safety observer's THUMBS-UP to provide an adequate safe launching procedure. The catapult officer shall not launch an aircraft until he receives a THUMBS-UP. *(Section IV, Paragraph A1a)*

2. An auxiliary deck-edge panel with adequate lights is needed to indicate the catapult status during emergency mode I operations. *(Section IV, Paragraph A1b)*

3. A signal to the pilot that the catapult is about to fire is desirable. *(Section IV, Paragraph A1c)*

4. The NAVAIRENGCEN MADIS has been updated to the latest configuration, but has not been tested. *(Section IV, Paragraph A2)*

5. C13 Mod 1 Catapult Design Change No. 250 and C13 Mod 1 Catapult Service Change No. 209 were satisfactorily tested on the TC13 Mod 1 catapult. *(Section IV, Paragraph A3)*

6. Three console status-light diode capsules failed in the PUSH-TO-TEST circuit, leaving both consoles incapacitated. *(Section IV, Paragraph A4)*

7. The console switch-cover hinges fail because their movement is limited to 90 degrees. *(Section IV, Paragraph A5)*

C. RRE

1. The desired individual catapult cycle time of 35 to 45 seconds cannot be attained unless the RRE cycle time is improved. *(Section IV, Paragraph B)*

2. Twenty of the 38 "critical" or Type I RRE failures were attributed to the bridle-tensioner pilot-valve solenoid and the grab latch. *(Section IV, Paragraph B1)*

3. The catapult FULL-AFT limit switch requires a new redesign and additional development testing. *(Section IV, Paragraph B2)*

4. An improved design of and additional development testing of the RRE drum anchor assembly are required to reduce catapult maintenance and to simplify preoperational checkout procedures. *(Section IV, Paragraph B3)*

5. The RRE hydraulic motor configured with the improved radial thrust bearing and the new purging system requires additional development tests. *(Section IV, Paragraph B4)*

D. CRO AND MARK 4 BRIDLE ARRESTER WITH AUTOMATIC BRIDLE RETRACTION

1. The CRO bridle arrester system was not able to support all catapult programs because of its limited performance range. The system is being redesigned; the redesigned system will require additional development testing. *(Section IV, Paragraph C1)*

2. The bridle arrester runout indicator system operated intermittently during the evaluation period and could not be adapted to the standard Mark 4 bridle-arrester system. Additional development tests will be conducted when the CRO bridle-arrester program is reinitiated. *(Section IV, Paragraph C2)*

3. The bridle deflector assemblies are not satisfactory for shipboard use. Because of the lack of an acceptable deflector unit, the automatic retraction program was discontinued until a need for automatic retraction develops in the Fleet. *(Section IV, Paragraph C4)*

E. VERTICAL ACCUMULATOR ASSEMBLY: This assembly performed satisfactorily in general; however, the stroke-control-actuator and volume-normal actuator assemblies require improvements. *(Section IV, Paragraph D)*

F. CSV: The CVN 68/CVN 69 type CSV system functioned satisfactorily. No serious problems were encountered which could not be solved by using the service manual. *(Section IV, Paragraph E)*

G. CCP: In general, the CCP operated satisfactorily; however, the light-selector-switch knobs and the isolation gauge globe valves require redesign and additional development tests. *(Section IV, Paragraph F)*

H. CJB: Electrical design and service changes were easily incorporated with minimal time and labor, which substantiates the initial intent of the CJB. *(Section IV, Paragraph G)*

I. ROTO-LAUNCHING VALVE: In general, the operation of the valve was satisfactory; however, the clock timer pressure switch requires additional development tests. *(Section IV, Paragraph H)*

J. DESI: The reliability and performance levels determined for the DESI system indicate that it is acceptable for shipboard use (see reference (i)); however, recent technological advances in microprocessor-type computers have resulted in a redesign of the DESI. Incorporation of the DESI system into the Fleet will be delayed pending test results of the new system. *(Section IV, Paragraph I)*

K. AUTO JBD: Although the auto JBD is mechanically satisfactory for shipboard use with NGL aircraft, its concept has been determined to be unsafe for flight-deck operations. Safety features in addition to those already installed will have to be incorporated to insure the overall safety for flight-deck personnel and aircraft. Until these features are incorporated and tested, the auto JBD will not be included as part of the associated CVN 68/CVN 69 equipment. *(Section IV, Paragraph J)*

VI. SUMMARY OF RECOMMENDATIONS

A. ICCS

1. The ICCS procedures should be amended to require that the catapult safety observer must see the aircraft lights or pilot salute before giving the THUMBS UP signal. The catapult officer shall not launch the aircraft until he receives the THUMBS UP signal.

2. The final auxiliary deck panel with adequate lights should be incorporated on the CVN 68/CVN 69 and later ships to indicate catapult status during emergency mode I operations.

3. The pilot signal lights should go from illuminated steady to flashing at FINAL READY to signal the pilot that the catapult is about to fire. This should be accomplished with the following provisos:

   a. The system should be modified to insure that operations are not interrupted if the flasher fails.

   b. The ship's forces should conclusively agree that the change is needed before it is installed.

4. The NAVAIRENGCEN MADIS should be updated to the latest configuration and tested before the system is returned to the ship.

5. Incorporate C13 Mod 1 Catapult Design Change No. 250 and C13 Mod 1 Catapult Service Change No. 209 on the CVN 68/CVN 69 and later vessels.

6. The console status-light diode-capsule failure problem should be investigated.

7. The console switch-cover specifications should be changed to provide 180 degrees of movement.

B. RRE

1. The design of the bridle-tensioner pilot-valve solenoid and the grab latch should be improved.

2. The catapult FULL-AFT limit switch should be redesigned and subjected to additional development testing.

3. The design of the drum anchor assembly should be improved.

4. The hydraulic motor should be developed further.

C. CRO AND MARK 4 BRIDLE ARRESTER WITH AUTOMATIC BRIDLE RETRACTION: Additional development testing of the redesigned system should be conducted.

D. VERTICAL ACCUMULATOR ASSEMBLY: The stroke-control-actuator and volume-normal assemblies should be improved.

E. CCP: The light-selector knobs and isolation gauge globe valves should be redesigned and subjected to additional development tests.

F. CJB: This unit should be incorporated in the Fleet.

G. ROTO-LAUNCHING VALVES: The clock timer pressure switch should be subjected to additional development tests.

H. AUTO JBD: Additional safety features should be incorporated on the automatic control of the JBD.

VII. REFERENCES

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(c) NAVAIRTESTFAC Report NATF-EN-1139 of 5 Aug 1976: Mark 2 Nose-Gear-Launch System Hardware Evaluation Report. AD A029020

(d) NAVAIRTESTFAC Report NATF-COS-3 of 22 Dec 1972: Analytical Techniques for Cyclical Equipment Exhibiting Reliability Growth

(e) NAVAIRTESTFAC Report NATF-E-1074 of 18 Mar 1965: The Applicability of Certain Distributions to Ship Installations Reliability and Maintainability Evaluations

(f) Epstein, Benjamin "Tests for the Validity of the Assumption that the Underlying Distribution of Life is Exponential". Part I, TECHNOMETRICS, V. 2, No. 1, Feb 1960

(g) Barlow, Richard E. and Scheuer, Ernest M. "Reliability Growth During a Development Testing Program". TECHNOMETRICS, V. 8, No. 1, Feb 1966

(h) NAVAIRTESTFAC Letter Report NATF-L172 of 15 Oct 1973: Installation and evaluation of C13 Mod 1 Catapult Design Change No. 251: Catapult officer and monitor console writing tops; installation of (Final Report)

(i) NAVAIRTESTFAC Letter Report NATF-L179 of 20 Mar 1974: Installation of C13 Mod 1 Catapult Service Change No. 182: Telephone selector switch and telephone jacks; removal of (Final Report)

(j) NAVAIRTESTFAC Letter Report NATF-L212 of 25 Jun 1976: Initial-installation evaluation of C13/C13 Mod 1 Catapult Service Change No. 298/234: Capacity selector valve spindle lock; provision for

(k) NAVAIRTESTFAC Letter Report NATF-L7 of 16 Jan 1968: Low-loss launch valve (roto-valves); interim report on

(l) NAVAIRTESTFAC Letter Report NATF-L105 of 16 Feb 1971: Low-loss launching valve (roto-valve); final report on inspection of

(m) NAVAIRTESTFAC Report NATF-EN-1126 of 10 Jul 1973: Evaluation of the DESI (Digital End-Speed Indicator) System. AD 912079L

(n) NAVAIRTESTFAC Report NATF-EN-1130 of 28 Feb 1974: Evaluation of the Automatic JBD (Jet Blast Deflector) System. AD 775665

APPENDIX A - TABLES LISTING TYPES I, II, AND III CATAPULT COMPONENT FAILURES

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TABLE AI - TYPE I FAILURE DATA IN CHRONOLOGICAL ORDER

Failure No. (Fi)	Evaluation Test Program Cycle No. (W)	Overall Catapult Launch No./Date	Type of Failure	Component (Name and Part No.)	Description of Failure Incident	Reason for Failure
1	0	18,292 23 Sep 1970	Assignable cause	Maneuver aft solenoid (EA) C95626	Maneuver aft solenoid required replacement because of erratic operation.	A number of solenoids were replaced prior to this replacement. This was the first replacement during the evaluation period. Solenoid plunger was gummed up from contaminated hydraulic fluid. Mission capability was reduced because failure interrupted catapult operations.
2	0	"	"	Maneuver fwd solenoid C95626	Maneuver fwd solenoid required replacement because of erratic operation.	Solenoid plunger was gummed up with dirt and contaminated hydraulic fluid. A number of these solenoids were replaced prior to this replacement. This was the first replacement during the evaluation period. Mission capability was degraded.
3	4	18,296 25 Sep 1970	"	"	Maneuver fwd solenoid required replacement because it overheated and burned out	The maneuver valve spool was binding, causing the solenoid to fail. Mission capability was degraded as in failure No. 2.
4	35	18,327 7 Oct 1970	"	"	"	See above notes for failure No. 3.
5	90	18,382 14 Oct 1970	"	"	"	No reason for the failure could be found. Mission capability was degraded as noted in failure No. 3; however, since this failure does not occur again, it is considered an "assignable cause" type of failure.
6	100	18,392 15 Oct 1970	Inherent	Maneuver valve 611038-3	Maneuver valve required replacement because of erratic operation.	Pilot section of valve was found binding easily. This was the first replacement during the evaluation period. A number of these valves were replaced prior to this replacement. Mission capability was degraded because the failure interrupted catapult operations. Although the failure was fixed, there is a reasonable possibility this type of failure will reoccur.
7	100	"	Assignable cause	Bridle tensioner pilot valve 611038-2	Valve required replacement because of erratic operation.	The pilot section was binding. A number of these valves were replaced prior to this replacement. This was the first replacement for this component during the evaluation period. Mission capability was degraded because the failure interrupted catapult operations.
8	169	18,461 23 Oct 1970	Inherent	Retract directional valve closing orifice 509547-3	RRE malfunctioned during retraction of the piston assemblies. Engine did not enter maneuver aft mode, causing pistons to slam into tensioner.	Failure interrupted catapult operations. Found orifice clogged with dirt. Mission capability was degraded because the failure interrupted catapult operations.
9	337	18,629 28 Dec 1970	Inherent	Grab latch spring 318439-1	Spring which retains the grab latch in the raised position failed and was replaced.	Failure degraded catapult operations. Unable to latch onto piston assemblies to retract, and mission could not be accomplished.
10	574	18,816 25 Jan 1971	Assignable cause	Bridle tensioner solenoid C95626	Replaced bridle tensioner solenoid because it overheated and burned out.	A number of these solenoids have been replaced prior to this replacement. This was the first replacement during the evaluation period. Mission capability was degraded because the failure interrupted catapult operations. Although the failure was fixed, a reasonable possibility exists that this type of failure will reoccur. No reason for the failure could be found at the time of the occurrence.

TABLE AI - TYPE I FAILURE DATA (CONTINUED)

Failure No. (Fi)	Evaluation Test Program Cycle No. (W)	Overall Catapult Launch No./Date	Type of Failure	Component (Name and Part No.)	Description of Failure Incident	Reason for Failure
11	625	18,917 10 Feb 1971	Inherent	Grab latch 508943-4	Latch was replaced because it broke while being hooked up to the piston assemblies during a launch.	A number of grab latches have broken prior to this replacement. This was the first replacement during the evaluation period. Mission capability was degraded because the failure interrupted catapult operations.
12	864	19,156 16 Mar 1971	Assignable cause	Bridle tensioner solenoid C95626	Replaced solenoid because it overheated and burned out.	No reason for the solenoid failure could be determined. Mission capability was degraded; see failure No. 10.
13	1171	19,463 21 Apr 1971	Inherent	Full-aft limit switch connector plug MS3106A1 45-6S (C)	Electrical short in connector plug caused RRE to stay in maneuver-aft mode. The electrical wire L-1 also shorted out to the wire that gives the safe light and exhaust valve malfunction light on the main control console. The plug was replaced.	This was the first failure of the evaluation period. Mission capability was degraded because the failure interrupted catapult operations. A number of these connector plugs were replaced prior to the evaluation period. The failure was fixed; however, a reasonable possibility exists this type of failure will reoccur.
14	1588	19,880 6 Jul 1971	Inherent	Grab latch 508943-4	Replaced broken grab latch which had broken during catapult no-load launch.	Mission capability was degraded as in failure No. 11. Although the failure was fixed, a reasonable possibility exists for this type of failure to reoccur. No known permanent cure for this failure could be determined at the time of the failure.
15	1688	19,980 19 Jul 1971	Inherent	"	Replaced shuttle grab latch which had failed during launch.	Grab latch was prematurely latched onto the catapult shuttle during launch. Mission capability was degraded as noted in failure No. 14. Although the failure was fixed, a reasonable possibility exists that this type of failure will reoccur. No known permanent cure for this failure could be determined at the time of occurrence.
16	1693	19,985 19 Jul 1971	Assignable cause	Bridle tensioner solenoid C95626	Replaced solenoid because it overheated and shorted out.	Hydraulic fluid leak above solenoid caused solenoid to short out. Mission capability was degraded. See failure No. 10.
17	1745	20,037 4 Aug 1971	"	"	Replaced solenoid which had overheated and burned out.	No reason at the time could be attributed to the solenoid failure. See failure No. 10.
18	2149	20,441 13 Sep 1971	Inherent	Retract cable 29-40707-520	Replaced starboard retract cable because it broke.	A number of cables were replaced prior to this replacement. This was the first replacement during the evaluation period. The cable never met the required 3,500-cycle replacement criterion. Mission capability was reduced because the failure interrupted catapult operations.
19	2236	20,528 4 Oct 1971	Assignable cause	Bridle tensioner solenoid C95626	Replaced solenoid which had overheated and burned out.	No reason could be attributed to the solenoid failure at the time. See failure No. 10.
20	3113	21,405 27 Dec 1971	Inherent	FDNGL buffer aft solenoid C95626	FDNGL buffer aft solenoid overheated and burned out; solenoid replaced.	No apparent reason for the failure could be determined. A number of these solenoids were replaced prior to this replacement. This was the first replacement during the evaluation period. Mission capability was degraded because the failure interrupted catapult operations. Although the failure was fixed, a reasonable possibility exists this type of failure will reoccur.

TABLE AI - TYPE I FAILURE DATA (CONTINUED)

Failure No. (Fi)	Evaluation Test Program Cycle No. (W)	Overall Catapult Launch No./Date	Type of Failure	Component (Name and Part No.)	Description of Failure Incident	Reason for Failure
21	3113	21,405 10 Jan 1972	Inherent	DESI stop sensor 420830-1	Replaced sensor which was damaged when shuttle magnet struck it.	This was the first failure during the evaluation for this component. Mission capability was degraded because the failure interrupted catapult operations.
22	3436	21,728 17 Feb 1972	Assignable cause	Bridle tensioner solenoid C95626	Solenoid overheated and burned out, and was replaced.	No apparent reason could be attributed to the solenoid failure. See failure No. 10.
23	3529	21,821 25 Feb 1972	Inherent	Grab latch 508943-4	Replaced shuttle grab latch which failed during launch.	See failure No. 14.
24	3538	21,830 28 Feb 1972	"	FDNGL spreader side plate 512246	The aircraft port landing gear ran over and bent the spreader side plate. Operations were discontinued until spreader was repaired.	During an abort procedure, the plane director inadvertently directed to turn the plane too soon and subsequently the port main landing gear crushed the spreader side plates. Mission capability was degraded because the failure interrupted catapult operations.
25	3594	21,886 27 Apr 1972	Assignable cause	Bridle tensioner solenoid C95626	Solenoid overheated and burned out, and was replaced.	No apparent reason could be attributed to the solenoid failure. See failure No. 10.
26	3622	21,914 10 May 1972	"	"	"	"
27	3782	22,074 5 Jun 1972	"	Vertical accumulator actuator assy limit switch 414580-1	Main hydraulic pumps would not go ON STROKE when system hydraulic pressure dropped below the minimum allowable working pressure. Switch was replaced.	The switch failed. This was the first failure of this component during the evaluation period. Mission capability was degraded because the failure interrupted catapult operations.
28	3822	22,114 12 Jun 1972	"	Bridle tensioner solenoid C95626	Replaced solenoid which had overheated and burned out.	No apparent reason could be attributed to the failure. See failure No. 10.
29	3841	22,133 14 Jun 1972	Inherent	Bridle tensioner pilot valve 611038-2	Valve actuated sluggishly, preventing proper catapult tensioning procedure. Valve was replaced.	Found sediment in valve from contaminated hydraulic fluid. Spring and end cap show signs of rusting. Mission capability was degraded because catapult operations were interrupted. Although the failure was fixed, a reasonable possibility exists this type of failure will reoccur.
30	3937	22,229 21 Jun 1972	"	Advance cable 29-40707-900	Port advance cable broke and had to be replaced.	The advance cables were installed for 3,937 catapult cycles which is beyond the required service-life limit of 3,500 cycles. Mission capability was degraded because this failure interrupted catapult operations. Although the failure was fixed, a reasonable possibility exists that this type of failure may reoccur.
31	3937	22,229 28 Jun 1972	Assignable cause	Bridle tensioner solenoid C95626	Replaced solenoid which had overheated and burned out.	No apparent cause for the failure could be determined. See failure No. 10.

TABLE AI - TYPE I FAILURE DATA (CONTINUED)

Failure No. (Fi)	Evaluation Test Program Cycle No. (W)	Overall Catapult Launch No./Date	Type of Failure	Component (Name and Part No.)	Description of Failure Incident	Reason for Failure
32	3968	22,260 18 Jul 1972	Assignable cause	Vertical accumulator ON-OFF stroke actuator rod 414569-1	Rod stuck and system hydraulic pressure could not be obtained.	Found dirt and rust between rod and gland. Rod was cleaned and returned to service. A number of these rods failed in a similar fashion prior to this failure. This was the first failure during the evaluation period. Mission capability was reduced because the failure interrupted catapult operations. Although the failure was fixed, a reasonable possibility exists that this failure will reoccur.
33	4415	22,707 16 Oct 1972	Inherent	DESI stop sensor 420830	Replaced DESI stop sensor which had malfunctioned.	Internal wire was found broken inside sensor. Mission capability was degraded because the failure interrupted catapult operations.
34	4513	22,805 13 Nov 1972	"	"	"	"
35	4586	22,878 5 Dec 1972	Assignable cause	Roto-launch valve clock timer start pressure switch (S580) 414314-1	Replaced pressure switch which malfunctioned and catapult could not be fired.	No apparent reason could be attributed for the failure. This was the first failure during the evaluation period. Mission capability was reduced because the failure interrupted catapult operations.
36	4623	22,915 19 Apr 1973	"	Vertical accumulator actuator rod 416940-1	Rod was broken and required replacement because system hydraulic pressure could not be obtained.	A piping tail piece was inadvertently left inside the accumulator and subsequently damaged the rod. Mission capability was degraded because the failure interrupted catapult operations.
37	4623	"	Inherent	Bridle tensioner pilot valve 611038-2	Replaced valve because of erratic operation causing improper tensioning of catapult.	Found pilot section of valve binding easily. Mission capability was degraded. See failure No. 29.
38	4679	22,971 4 May 1973	"	"	"	"
39	4700	22,992 25 May 1973	"	Vertical accumulator volume normal actuator assy 612731-1	Assembly was replaced because it malfunctioned. This interrupted the catapult launching sequence because catapult interlock could not be obtained.	This failure was caused by the incident failure No. 32; however, only the actuator rod was replaced at the time because volume normal light on the main console was obtained, which allowed the catapult to be fired.
40	4704	22,996 3 Jul 1973	Assignable cause	Roto-launch valve clock timer start pressure switch (S580) 414314-1	Replaced pressure switch which had failed and catapult could not be fired.	No apparent reason for the failure could be attributed for this failure. Mission capability was degraded as in failure No. 35. Although the failure was fixed, a reasonable possibility exists that this failure will reoccur.
41	4971	23,263 8 Aug 1973	"	Deck tensioner assembly 613665	Replaced the deck tensioner because catapult tensioning could not be obtained when the tensioner piston was expelled out of the tensioner housing.	The tensioner piston-to-piston rod bolts failed. Because the speed of the tensioner is twice as fast as the old type tensioner, it caused the bolts to fail. The tensioner flange has since been strengthened and 8 bolts in lieu of 4 bolts are used. As a precautionary measure, a control orifice was also installed in the fluid piping to slow down the tensioner. Because the defect is fixed and this type of failure does not occur again, it is considered an assignable cause type of failure.

TABLE AI - TYPE I FAILURE DATA (CONTINUED)

Failure No. (Fi)	Evaluation Test Program Cycle No. (W)	Overall Catapult Launch No./Date	Type of Failure	Component (Name and Part No.)	Description of Failure Incident	Reason for Failure
42	4989	23,281 15 Aug 1973	Assignable cause	FDNGL buffer fwd solenoid C95626	Replaced solenoid because it overheated and burned out.	No apparent reason for the failure could be found. Mission capability was degraded because this failure interrupted catapult operations. A number of these solenoids was replaced prior to this replacement; however, this was the first replacement during the evaluation period. Although the failure was fixed, a reasonable possibility exists this failure will reoccur.
43	5194	23,486 19 Sep 1973	"	Roto-launch valve clock timer start pressure switch (S580) 414314-1	Pressure switch malfunctioned and had to be replaced.	No apparent reason for the failure could be found. See failure No. 40.
44	5507	23,799 1 Oct 1973	"	FDNGL buffer aft solenoid C95626	Replaced solenoid which overheated and burned out.	No apparent reason for the failure could be found. Mission capability was degraded as noted in failure No. 20; however, only the first incident is counted as a failure. Repeated incidents are not counted because a redesign will be made. This is an assignable-cause type of failure.
45	5803	24,095 11 Oct 1973	"	FDNGL buffer fwd solenoid C95626	"	No apparent reason could be attributed to the failure. Mission capability was degraded. See failure No. 42.
46	6021	24,313 25 Oct 1973	Inherent	RRE port retract cable 29-40707-520	The port retract cable broke and both port and stbd cables were replaced.	The retract cables had 4,296 catapult cycles on them. Cables should have been changed after 3,500 cycles.
47	6809	25,101 7 Dec 1973	Assignable cause	FDNGL buffer fwd solenoid C95626	Replaced solenoid which overheated and burned out.	No apparent reason could be attributed to the failure. See failure No. 42.
48	6822	25,114 7 Dec 1973	Inherent	Grab latch 508943-4	Latch broke and was replaced.	Catapult was fired with grab assembly attached to piston assembly. See failure No. 14.
49	7075	25,367 29 Mar 1974	Assignable cause	Vertical accumulator actuator limit switch 414580-1	Switch malfunctioned and was replaced.	No apparent reason could be attributed to the switch malfunction. Mission capability was degraded as in failure No. 27; however, only the first incident is counted as a failure. Repeated incidents are not counted because redesign will be made. This is an assignable-cause type of failure.
50	7350	25,642 10 Apr 1974	Inherent	ICCS monitor console low-pressure air green status light diode capsule 418792-1	Capsule shorted out, causing all panel lights to go out. Capsule was replaced.	No apparent reason for the capsule to fail could be found. This was the first replacement during the evaluation period. A number of these capsules was replaced prior to this replacement. Mission capability was degraded because the failure interrupted catapult operations.
51	7809	26,101 12 Jul 1974	"	RRE full-aft limit switch (S854) 413996-1	Switch failed and was replaced because catapult interlock could not be obtained.	A number of these switches was replaced prior to the evaluation period. This was the first switch failure of the evaluation period. Mission capability was degraded because the failure interrupted catapult operations.
52	7846	26,138 23 Jul 1974	Assignable cause	Roto-launch valve clock timer start pressure switch (S580) 414314-1	Replaced pressure switch because it malfunctioned and catapult could not be fired.	No apparent reason for the switch malfunction could be found. Because the failure was fixed and this type of failure does not reoccur, it is considered an assignable-cause type of failure.

TABLE AI - TYPE I FAILURE DATA (CONTINUED)

Failure No. (Fi)	Evaluation Test Program Cycle No. (W)	Overall Catapult Launch No./Date	Type of Failure	Component (Name and Part No.)	Description of Failure Incident	Reason for Failure
53	7853	26,145 26 Jul 1974	Assignable cause	Bridle tensioner solenoid C95626	Replaced solenoid which overheated and burned out.	No apparent reason for the failure could be found. See failure No. 10.
54	8176	26,468 3 Oct 1974	Inherent	ICCS monitor console lube pump pressure green status light diode capsule 418792-1	Capsule shorted out, causing all panel lights to go out. Capsule was replaced.	No reason for the failure could be found This was the first replacement during the evaluation period. A number of these capsules were replaced prior to this replacement. Mission capability was degraded because the failure interrupted catapult operations.
55	8185	26,477 14 Nov 1974	Assignable cause	Vertical accumulator actuator rod 416940-1	Rod was bent, causing the main hydraulic pumps to go ON and OFF stroke improperly. Proper system hydraulic pressure could not be achieved and rod was replaced.	No apparent reason could be found to cause the rod to bend. Mission capability was degraded because the failure interrupted catapult operations. Although the failure was fixed, a reasonable possibility exists this failure will reoccur.
56	8286	26,578 25 Nov 1974	"	Bridle tensioner solenoid C95626	Replaced solenoid which overheated and burned out.	No apparent reason for the failure could be found. Because the defect was fixed and this type of failure did not reoccur, it is considered an assignable-cause type of failure.
57	8358	26,650 17 Dec 1974	Inherent	ICCS monitor console hydraulic pressure green light diode 418792-1	Replaced hydraulic pressure status light which gave false indication.	No reason for the failure could be found. This was the first replacement during the evaluation period. A number of these capsules were replaced prior to this replacement. Mission capability was degraded because the failure interrupted catapult operations.
58	8762	27,054 7 Apr 1975	"	Port advance cable EO 71-697 (6x37)	Port advance cable broke and was replaced	The advance cables had 4,146 catapult cycles on them. Cables should have been changed after 3,500 cycles.
59	8933	27,225 1 May 1975	Assignable cause	FDNGL buffer fwd solenoid C95626	Replaced solenoid which overheated and burned out.	No reason for the failure could be found. See failure No. 42.
60	9168	27,460 10 Jun 1975	Inherent	Grab latch 508943-4	Replaced broken grab latch.	No reason for the failure could be found. Mission capability was degraded. See failure No. 14.
61	9753	28,045 7 Jul 1975	"	"	"	Grab latch failed when catapult was fired with grab assembly hooked up to the shuttle. Mission capability was degraded because the failure interrupted catapult operations.
62	9753	28,045 8 Jul 1975	Assignable cause	FDNGL buffer fwd solenoid C95626	Replaced solenoid which overheated and burned out.	No reason for the failure could be found. Because the failure was fixed and this type of failure does not occur again, it is considered an assignable-cause type of failure.
63	10617	28,909 8 Sep 1975	Inherent	CJB fire relay (R28) 509514	Relay burned out and was replaced.	No apparent reason for the relay failure could be found. Mission capability was degraded because catapult operations were interrupted.
64	10772	29,064 6 Oct 1975	"	RRE hydraulic motor radial-thrust bearing Vickers Co. 101847	RRE hydraulic motor emitted loud noises and stopped. Motor was replaced.	Radial end thrust bearings disintegrated, causing the motor to fail. Mission capability was degraded because catapult operations were interrupted.

TABLE AII - CATAPULT COMPONENT TYPE I FAILURES LISTED BY SUBASSEMBLY GROUPS (16 AUG 1970 THROUGH 31 MAR 1976, CATAPULT LAUNCH 18,292 THROUGH 29,350)

Component (Part No. and Name)	Date of Failure	Catapult Launch No.	Time to Repair Man-Hours	Time to Repair Actual Hours	Description of Failure
ICCS					
478792-1 Monitor console lube pump pressure green status light diode capsule	3 Oct 1974	26,468	0.5	0.5	Capsule shorted and caused all panel lights to light.
418792-1 Monitor console low-pressure air green status light diode capsule	10 Apr 1974	25,642	1.0	1.0	"
418792-1 Monitor console hydraulic pressure green light diode	17 Dec 1974	26,650	1.0	1.0	Light failed to light.
RRE (ROTARY RETRACTION ENGINE)					
Vickers Co. 101847 Hydraulic motor radial thrust bearing	6 Oct 1975	29,064	100.0	20.0	Bearings disintegrated and RRE stopped. Replaced with spare motors.
NAEC 611038-2 Bridle tensioner pilot valve	15 Oct 1970	18,392	1.5	1.5	Replaced bridle-tensioner pilot valve because of erratic operation. Found pilot section binding easily.
	14 Jun 1972	22,133	1.5	1.5	
	19 Apr 1973	22,915	1.0	1.0	
	4 May 1973	22,971	2.0	1.0	
Rivett C95626-115-60 Bridle-tensioner solenoid	25 Jan 1971	18,816	1.0	0.5	Replaced solenoid because it overheated and shorted out.
	16 Mar 1971	19,156	1.0	0.5	
	19 Jul 1971	19,985	1.0	0.5	Replaced solenoid because it overheated and shorted out. Hydraulic leak above solenoid caused short.
	4 Aug 1971	20,037	1.0	0.5	Replaced solenoid because it overheated and burned out.
	4 Oct 1971	20,528	1.0	0.5	"
	17 Feb 1972	21,728	1.0	0.5	"
	27 Apr 1972	21,886	1.0	0.5	"
	10 May 1972	21,914	1.0	0.5	"
	12 Jun 1972	22,114	1.0	0.5	"
	28 Jun 1972	22,229	1.0	0.5	"
	26 Jul 1974	26,145	1.0	0.5	"
	25 Nov 1974	26,578	1.0	0.5	"
509547-3 Retract directional valve closing orifice	23 Oct 1970	18,461	1.0	0.5	RRE malfunctioned during retract. Engine did not enter maneuver aft. Found retract directional valve closing orifice clogged.
611038-3 Maneuver valve	15 Oct 1970	18,392	2.0	1.0	Replaced valve because of erratic operation. Found pilot section of valve binding easily.
C95626 Maneuver forward solenoid (EF)	23 Sep 1970	18,292	1.0	0.5	Replaced solenoid because of erratic operation.
	25 Sep 1970	18,296	1.0	0.5	Replaced solenoid because it overheated excessively.
	7 Oct 1970	18,327	1.0	0.5	Replaced solenoid because it overheated and shorted out.
	14 Oct 1970	18,382	1.0	0.5	

TABLE AII - TYPE I FAILURES (CONTINUED)

Component (Part No. and Name)	Date of Failure	Catapult Launch No.	Time to Repair Man-Hours	Time to Repair Actual Hours	Description of Failure
RRE (ROTARY RETRACTION ENGINE) (CONT'D)					
C95626 Maneuver aft solenoid (EA)	23 Sep 1970	18,292	1.0	0.5	Replaced solenoid because of erratic operation.
	21 Apr 1971	19,463	1.0	0.5	Replaced solenoid because it overheated and shorted out.
NAEC 413996-1 (S854) Full-aft limit switch	12 Jul 1974	26,101	9.0	5.0	Replaced switch and cable. Soldered connections at switch worked loose and rotated.
29-40707-520-0 Retract cables	13 Sep 1971	20,441	32.0	8.0	Starboard retract cable broke.
	25 Oct 1973	24,313	108.0	16.0	Port retract cable broke. Replaced both cables with EO 6x37 strand.
29-40707-900-0 Advance cables	21 Jun 1972	22,229	280.0	80.0	Port advance cable broke. Replaced both cables.
EO 71-797 (6x37) Advance cables	7 Apr 1975	27,054	200.0	40.0	Port advance cable broke. Replaced with EO 71-791 (6x37) type.
508943-4 Grab latch	10 Feb 1971	18,917	12.0	2.4	Replaced grab latch because it did not break from shuttle.
	6 Jul 1971	19,880	12.0	2.4	"
	19 Jul 1971	19,980	12.0	2.4	"
	25 Feb 1972	21,821	12.0	2.4	Replaced damaged grab latch.
	7 Dec 1973	25,114	12.0	2.4	Replaced broken grab latch. Catapult fired with grab attached to shuttle.
	10 Jun 1975	27,460	12.0	2.4	Replaced broken grab latch.
	7 Jul 1975	28,045	12.0	2.4	Replaced broken grab latch. Catapult fired with grab.
318439-1 Grab latch spring	28 Dec 1970	18,629	12.0	2.4	Spring which retains the grab latch in the raised position failed and was replaced.
FDNGL (FLUSH-DECK NOSE GEAR LAUNCH)					
HMP 1C520-187 Buffer aft solenoid	27 Dec 1971	21,405	1.0	0.5	Replaced burned out solenoid.
512246 Nose-tow spreader side plate	28 Feb 1972	21,830	6.0	2.0	Aircraft port landing gear ran over and bent spreader side plate.
613665 Deck-tensioner assembly	8 Aug 1973	23,263	48.0	16.0	Tensioner-piston-to-piston-rod bolts failed.
HMP 1C520-187 Buffer fwd assembly	15 Aug 1973	23,281	1.0	0.5	Replaced burned out solenoid.
HMP 1C520-187 Buffer aft solenoid	1 Oct 1973	23,799	1.0	0.5	"
HMP 1C520-187 Buffer fwd solenoid	11 Oct 1973	24,095	1.0	0.5	"
	7 Dec 1973	25,101	1.0	0.5	"
	1 May 1975	27,225	1.0	0.5	"
	8 Jul 1975	28,045	1.0	0.5	"

TABLE AII - TYPE I FAILURES (CONTINUED)

Component (Part No. and Name)	Date of Failure	Catapult Launch No.	Time to Repair Man-Hours	Time to Repair Actual Hours	Description of Failure
ROTO-LAUNCH VALVE					
414314-1 (S580)	5 Dec 1972	22,878	1.0	0.5	Pressure switch malfunctioned.
Roto-launch-valve	3 Jul 1973	22,996	1.0	0.5	Replaced to correct problem.
clock timer start	19 Sep 1973	23,486	1.0	0.5	"
pressure switch	23 Jul 1974	26,138	1.0	0.5	"
VERTICAL ACCUMULATOR					
416940-1 Actuator rod	19 Apr 1973	22,915	1.0	1.0	Replaced rod which broke when tail piece was left in accumulator.
	14 Nov 1973	26,477	1.0	1.0	Rod was bent, causing the pump to go ON and OFF STROKE improperly. Replaced rod.
612731-1 Volume normal actuator assembly	25 May 1973	22,992	4.0	2.0	Replaced assembly because of damage caused when tail piece was accidently left in accumulator on 19 Apr 1973.
414580-1 Actuator assembly limit switch	5 Jun 1972	22,074	1.0	1.0	Replaced switch because of malfunction.
	29 Mar 1974	25,367	1.0	1.0	
414569-1 ON-OFF STROKE actuator rod	18 Jul 1972	22,260	4.0	4.0	Rod stuck. Found dirt and rust between rod and gland. Cleaned up and returned to service.
CJB (CENTRAL JUNCTION BOX)					
509514 R28 fire relay CJB	8 Sep 1975	28,909	1.0	1.0	Fire relay burned out. Replaced to correct problem.
DESI (DIGITAL END-SPEED INDICATOR)					
420830-1 Stop sensor	10 Jan 1972	21,405	3.0	1.0	Sensor hit and damaged by shuttle magnet.
420830 Stop sensor	16 Oct 1972	22,707	3.0	1.0	Internal broken wire.
420830 Start sensor	13 Nov 1972	22,805	3.0	1.0	Internal broken wire.

TABLE AIII - CATAPULT COMPONENT TYPE II FAILURES LISTED BY SUBASSEMBLY GROUPS (16 AUG 1970 THROUGH 31 MAR 1976, CATAPULT LAUNCH 18,292 THROUGH 29,350)

Component (Part No. and Name)	Date of Failure	Catapult Launch No.	Time to Repair Man-Hours	Time to Repair Actual Hours	Description of Failure
ICCS					
413772-2 Fire push-button safety cover hinge	21 Nov 1972	22.858	0.5	0.5	Hinge failed and entire assembly was replaced.
	14 Jun 1974	25,977	0.5	0.5	"
	27 Nov 1974	26,578	0.2	0.2	"
515151-1 Deck suspend light flasher	8 May 1972	21,908	1.0	1.0	Light flasher failed and was replaced.
	1 Aug 1974	26,200	0.5	0.5	"
	26 Mar 1975	27,008	0.1	0.1	"
C508681-27 Monitor console retract permissive light diode capsule	5 Oct 1971	20,541	1.0	1.0	Capsule failed and was replaced.
616263-2 Deck suspend light	28 Jul 1972	22,301	2.0	2.0	Light failed and was replaced.
418510-1 Military power deck light lens	12 Dec 1974	26,642	1.0	1.0	Lens was roughened by the environment which reduced the brilliance of the light. The lens, gaskets, and bulb were replaced.
CRO AND MARK 4 BRIDLE ARRESTER					
504821-1 Strap	19 Feb 1971	18,930	6.0	2.0	Replaced broken strap.
	17 Sep 1971	20,518	6.0	2.0	"
	19 Jul 1973	23,125	6.0	2.0	Replaced broken strap with new strap.
	19 Sep 1973	23,485	6.0	3.0	Repaired strap, to remove severe kink cut off 42 inches.
	3 Nov 1975	29,251	6.0	2.0	Replaced broken strap with new strap.
MS28720 Filter	8 Sep 1971	20,345	0.5	0.5	Replaced dirty filter.
	16 Nov 1971	21,131	0.5	0.5	"
	15 Feb 1972	21,179	0.5	0.5	"
	4 Mar 1975	26,992	0.5	0.5	"
	21 Nov 1975	29,310	0.5	0.5	"
408756 Cooling water pump	5 May 1972	21,904	4.0	2.0	Replaced water cooling pump because it was worn out.
	14 Nov 1975	29,295	1.0	0.5	Replaced worn out pump.
509675 Secondary brake regulator	17 Apr 1974	25,742	0.5	0.5	Replaced regulator because of a malfunction.
	2 Jul 1974	26,075	0.5	0.5	Replaced blown regulator and pressure gauge.
	7 Nov 1975	29,260	0.5	0.5	Replaced broken regulator.
408364 Primary regulator	17 Feb 1973	23,009	0.5	0.5	Replaced regulator because of lack of control.
	6 May 1974	25,830	0.5	0.5	Replaced failed regulator.
	27 Jun 1974	26,040	0.5	0.5	"
614287 Cam setting adaptor assembly	4 Jan 1971	18,633	3.0	2.0	Replaced relaxed spring and damaged/worn clutch sections.
	7 May 1975	27,233	4.0	2.0	Replaced O-rings to repair leak.

TABLE AIII - TYPE II FAILURES (CONTINUED)

Component (Part No. and Name)	Date of Failure	Catapult Launch No.	Time to Repair Man-Hours	Time to Repair Actual Hours	Description of Failure
CRO AND MARK 4 BRIDLE ARRESTER (CONT'D)					
509546 Bridle arrester retract motor piping	2 May 1975	27,239	0.5	0.5	Replaced leaking O-ring on motor piping.
617391 Third brake pressure regulator	11 Dec 1975	29,350	0.5	0.5	Replaced blown regulator.
504970 Brake valve	9 Oct 1975	29,070	2.0	1.0	Primary brake valve stuck. Rebuilt with new seals.
N/A Electrical junction box	2 Dec 1971	21,233	2.0	2.0	Dried out water from junction box.
ROTO-LAUNCH VALVE					
N/A Lube fitting	10 Oct 1972	22,680	8.0	8.0	Replaced lube fitting which broke off, to stop steam leak. Steam receiver and water must be blown off and receiver charged again to accomplish this repair.
ROTARY RETRACTION ENGINE					
C95626 Retract solenoid pilot valve	22 Oct 1971	20,695	1.0	1.0	Double "A" valve replaced with Rivett valve retract. Solenoid burned out.
	18 Nov 1974	26,570	0.5	0.5	Replaced burned-out retract solenoid.
AN6227-9 O-ring internal tensioning blocking valve	9 Feb 1970	18,031	6.0	6.0	Hydraulic leak developed at the internal tensioning blocking valve inlet piping. Installed new one.
EO 71-797 (6x37) Port retract cable	2 May 1974	25,824	32.0	8.0	Replaced port retract cable. Sheave froze and cable developed severe flat spots.
VERTICAL ACCUMULATOR					
Stroke control actuator rod roller bearing					
MS24465-4	20 Sep 1971	20,518	4.0	4.0	Replaced bearing because it was rusted and binding.
414578-2	18 Jul 1972	22,260	16.0	8.0	"
B90781-33	17 Oct 1974	26,477	3.0	3.0	"
C90280-25 Stroke control actuator flat-head pin	15 Sep 1970	18,292	8.0	4.0	Replaced pin because it was badly worn. No spares available; pin fabricated.
	20 Sep 1971	20,518	8.0	4.0	Replaced rusted and binding pin.
	18 Jul 1972	22,260	16.0	8.0	"
	17 Oct 1974	26,477	3.0	1.5	"

N/A = Part No. not available.

TABLE AIII - TYPE II FAILURES (CONTINUED)

Component (Part No. and Name)	Date of Failure	Catapult Launch No.	Time to Repair Man-Hours	Time to Repair Actual Hours	Description of Failure
VERTICAL ACCUMULATOR (CONT'D)					
414573-1 Hydraulic piston vertical accumulator O-ring	20 Sep 1972	22,610	16.0	8.0	Found O-ring on air side of piston cut through in one place, and the other 2 rings were twisted and abraded. Replaced O-rings. Repacked new piston O-ring because of leakage.
B90781-33 Stroke control arm bearing	20 Sep 1971	20,518	4.0	4.0	Replaced bearing--rusted and binding.
	18 Jul 1972	22,260	16.0	8.0	"
	17 Oct 1974	26,477	3.0	1.5	"
509476-1 Stroke control actuator assembly gland	18 Jul 1972	22,260	16.0	8.0	Replaced gland--rusted and worn.
CSV (CAPACITY SELECTOR VALVE)					
17-42052-1 CSV stem	28 Mar 1972	21,880	4.0	2.0	Stem found worn. This stem mates to the CSV spindle.
614958-3 CSV mechanical counter	20 Jan 1972	21,452	1.0	1.0	Shaft in mechanical counter broke. Relied on encoder setting for catapult launches.
5181C100B 3AA CSV 440-volt supply relay	13 Oct 1970	18,362	0.5	0.5	Replaced failed relay.
614067-5 CSV shaft encoder	28 Feb 1975	26,992	2.0	2.0	Replaced encoder because of malfunction.
514680-2 Catapult officer's console CSV command unit	21 Mar 1972	21,880	1.0	1.0	100's column of position digit replaced because of malfunction.
616390-1 CSV circuit assembly	6 Nov 1975	29,257	6.0	3.0	Replaced circuit assembly because of malfunction.
CCP (CENTRAL CHARGING PANEL)					
414314-1 Bridle tensioner GO/NO GO pressure switch	24 Aug 1972	22,449	2.0	1.0	Replaced tensioner status pressure switch.
507655-1 Launch valve clock timer	17 Apr 1973	22,911	1.5	1.5	Replaced broken clock timer.
N/A CCP steam piping to gauges	16 Oct 1974	26,478	2.5	2.5	Pipe developed leak and was replaced.
B316415-1 Bridle tensioner accumulator hydraulic/dome air duplex gauge	22 May 1974	25,889	0.5	0.5	Gauge was reading erratically and was replaced.

N/A = Part No. not available.

TABLE AIII - TYPE II FAILURES (CONTINUED)

Component (Part No. and Name)	Date of Failure	Catapult Launch No.	Time to Repair Man-Hours	Time to Repair Actual Hours	Description of Failure
CCP (CENTRAL CHARGING PANEL) (CONT'D)					
514340-2 Bridle tensioner air pressure gauge hose for surge accumulator	4 May 1973 3 May 1974	22,971 25,824	1.0 1.0	1.0 1.0	Replaced failed hose. "
D89789-3 FDNGL hydraulic accumulator pressure gauge	15 May 1975	27,389	1.0	1.0	Gauge was subjected to twice its maximum pressure during extended buffer forward cycle.
A509519-6 FDNGL accumulator F/KI air charging F/KH blowdown valves	14 Aug 1972	22,449	1.5	1.5	Replaced valves which were badly corroded and rusted; could not turn handle.
DESI (DIGITAL END-SPEED INDICATOR)					
515837 Printer circuit card	6 Aug 1974	26,221	0.5	0.5	Printer circuit board burned out resulting in failure of shot count to increment, E/S was not affected.
618127-1 Data receiver card	9 Dec 1974	26,604	0.5	0.5	Burned card resulted in failure of remote readout.
618128-1 Decoder driver card	9 Dec 1974	26,604	0.5	0.5	"

TABLE AIV - CATAPULT COMPONENT TYPE III FAILURES LISTED BY SUBASSEMBLY GROUPS (16 AUG 1970 THROUGH 31 MAR 1976, CATAPULT LAUNCH 18,292 THROUGH 29,350)

Component (Part No. and Name)	Date of Failure	Catapult Launch No.	Time to Repair Man-Hours	Time to Repair Actual Hours	Description of Failure
CRO AND MARK 4 BRIDLE ARRESTER					
504892 Reservoir Assembly	14 Nov 1975	29,295	4.0	2.0	Drained, cleaned, and refilled assembly because fluid was dirty.
407809 Two-way valve	21 Nov 1975	29,310	1.0	1.0	Replaced damaged/leaking valve.
510678 High/low energy valve	12 Nov 1975	29,278	2.0	2.0	Repaired corroded cam shaft.
408515 Pressure-up switch	3 Apr 1974	25,660	0.5	0.5	Replaced burned out switch.
	10 Nov 1975	29,266	0.5	0.5	Refurbished electrical portion of pressure switch because of dirty contacts.
609591 Main engine assembly	28 Apr 1972	21,894	32.0	16.0	Rebuilt main B/A engine with new bearings, seals, etc., overhaul.
	5 Nov 1975	29,257	0.5	0.5	Repaired two piping O-ring joints.
413554 Cam setting assembly	3 Oct 1972	22,636	1.5	1.0	Replaced damaged cam setting adaptor.
	20 Mar 1974	25,632	2.0	1.0	Replaced weak reset spring.
411985 Brake pucks	17 Mar 1971	19,177	3.0	1.5	Puck worn--required replacement.
	20 Sep 1971	20,518	3.0	1.5	"
	2 Jul 1974	26,075	3.0	1.5	"
	19 May 1975	27,397	18.0	6.0	Replaced pucks because brake disc was replaced.
	26 Jan 1976	29,350	18.0	6.0	"
B408289 Cam reset limit switch (LS-2)	5 Nov 1970	18,463	0.5	0.5	Replaced failed limit switch, no cam reset light.
	2 Apr 1971	19,244	0.5	0.5	Replaced burned out switch.
	22 Sep 1971	20,528	0.5	0.5	"
	5 Mar 1974	25,530	0.5	0.5	Replaced corroded and shorted switch.
	17 Jul 1974	26,106	0.5	0.5	Replaced burned out limit switch.
506857 Brake disc	19 May 1975	27,397	18.0	6.0	Replaced brake disc because of grooves in disc.
	26 Jan 1976	29,350	12.0	6.0	Replaced worn brake disc and rebuilt calibers.
507737 Brake assembly	5 Oct 1972	22,637	6.0	3.0	Rebuilt brake assembly with new O-rings.
N/A Rubber hose to water reservoir	3 Oct 1972	22,636	0.5	0.5	Replaced clogged hose with new solid piping.
A408017 Solenoid valve	6 Sep 1972	22,528	1.0	0.5	Replaced retract solenoid valve because solenoid burned out.
609019 B/A track	19 Feb 1971	18,930	8.0	4.0	Aligned track to correct slot widths.
	8 Feb 1972	20,345	6.0	2.0	Repaired broken track fastening bolts in runout area.
	17 Sep 1971	20,518	6.0	2.0	
	13 May 1975	27,382	3.0	1.0	Replaced damaged track sections.
	31 Oct 1975	29,188	6.0	2.0	Repaired damaged fastening bolt holes by welding and tapping.
316081 Secondary brake pressure accumulator	2 Jul 1974	26,075	0.5	0.5	Replaced leaking surge accumulator.
503781 Idler drum assembly	2 May 1975	27,239	8.0	4.0	Replaced damaged idler drum.

TABLE AIV - TYPE III FAILURES (CONTINUED)

Component (Part No. and Name)	Date of Failure	Catapult Launch No.	Time to Repair Man-Hours	Time to Repair Actual Hours	Description of Failure
FDNGL (FLUSH DECK NOSE GEAR LAUNCH)					
510872 Slider Assembly	12 Aug 1975	28,674	2.0	1.0	Replaced ball plunger.
511010 Drain Pan Assembly	22 Oct 1970	18,461	24.0	8.0	Replaced leaking drain pan seals.
	18 Feb 1971	18,923	24.0	8.0	"
	10 Feb 1972	21,693	24.0	8.0	"
	16 Apr 1973	22,907	24.0	8.0	"
	14 Sep 1973	23,476	24.0	8.0	"
	15 Oct 1973	24,104	24.0	8.0	"
	12 Apr 1974	25,717	24.0	8.0	"
	13 May 1974	25,868	24.0	8.0	"
	7 Jan 1975	26,698	24.0	8.0	"
	19 Mar 1975	26,992	24.0	8.0	"
	12 Sep 1975	29,043	24.0	8.0	"
613474 Nose Gear Launch Assembly	29 Oct 1970	18,461	80.0	24.0	Replaced all buffer tensioner and shock absorber packing.
	26 Jul 1971	20,036	24.0	8.0	Replaced a total of ten sheared bolts due to thermal expansion.
	24 Jun 1975	27,819	1.0	1.0	Replaced aft buffer piping seals.
510311 Approach Track	11 Dec 1974	26,627	3.0	1.0	The approach track was hard ground to permit the acft launch bar to taxi over track joint in the flight deck.
416329 Slider Hook Assembly	24 Sep 1974	26,464	2.0	2.0	Replaced actuator roller and shaft.
513232 Solenoid Valve	27 Dec 1971	21,405	2.0	1.0	Replaced leaking valve to manifold O-rings.
	5 Oct 1973	23,895	1.0	0.5	Replaced leaking valve end-cap O-ring.
	11 Jan 1974	25,300	2.0	1.0	Replaced valve to manifold O-rings to repair leaks.
511001 Shock Absorber Assembly	3 Dec 1970	18,569	6.0	3.0	Rebuilt sticking shock absorber assembly.
	17 Dec 1970	18,605	6.0	3.0	"
	13 Jan 1971	18,747	6.0	3.0	Straightened out bent piston rod.
	18 Jan 1971	18,778	6.0	3.0	Straightened out bent piston rod, brake housing, installed new assy.
	20 Apr 1971	19,463	6.0	3.0	Replaced damaged shock absorber with solid block for 500 cycles.
	6 Aug 1971	20,097	6.0	3.0	Replaced leaking piston rod packing.
	24 Aug 1971	20,254	8.0	4.0	Rebuilt leaking/sticking assembly.
	14 Oct 1971	20,659	6.0	3.0	Replaced damaged shock absorber with new unit.
	19 Oct 1971	20,682	6.0	3.0	Replaced damaged shock absorber with solid block for 174 events.
	26 Jul 1973	23,156	16.0	8.0	Rebuilt leaking unit--used new type of fluid and all new seals.
A408573-4 Slide Assembly Ball Plunger	4 May 1973	22,971	6.0	4.0	Adjusted ball plunger to permit slider hook to remain actuated.
613665 Deck Tensioner Assembly	21 Oct 1970	18,461	10.0	3.0	Replaced leaking piston rod packing.
	22 Dec 1970	18,625	10.0	3.0	"
	8 Mar 1971	19,039	10.0	3.0	"
	29 Dec 1971	21,405	10.0	3.0	"
	16 Apr 1973	22,907	16.0	8.0	Rebuilt leaking quick-disconnect couplings.

TABLE AIV - TYPE III FAILURES (CONTINUED)

Component (Part No. and Name)	Date of Failure	Catapult Launch No.	Time to Repair Man-Hours	Time to Repair Actual Hours	Description of Failure
FDNGL (CONTINUED)					
M8805/41 Nose Gear Launch Ready Switch	14 Feb 1973	22,907	6.0	3.0	Replaced burned out limit switch.
514828 Slide Assembly Lever	22 May 1972	22,007	16.0	12.0	Relocated misplaced detent positions by machining.
B414463-29 Stop Bolts	31 Mar 1972	21,880	3.0	1.0	Replaced bent stop bolts.
60902-1 Ready Light	11 May 1973	22,986	12.0	6.0	Disassembled and cleaned light.
615845 Manifold Assembly	16 Nov 1973	24,816	0.5	0.5	Replaced manifold piping O-ring.
RRE (ROTARY RETRACTION ENGINE)					
AN6227-37	22 Dec 1971	20,018	5.0	5.0	Replaced leaking O-ring.
O-ring Starboard	21 May 1973	23,678	6.0	3.0	"
Cable Tensioner	24 Jul 1975	35,168	4.0	2.0	"
AN6227-37 O-ring Port Retract Cable Tensioner	2 May 1974	29,760	16.0	8.0	"
414602-1 Traverse Carriage Slippers	27 Jul 1971	17,018	24.0	8.0	Replaced slippers--below allowable 11/32 inch clearance.
508469-1 Cable Tensioner Accumulator	28 Jul 1971	17,018	2.0	1.0	Accumulator well pitted on air side; piston cracked and pitted on air side. Replaced with new accumulator 508469-2.
	11 Apr 1975	32,364	3.0	1.0	Accumulator was rusted and pitted on air side, causing internal leakage.
513130-1 Drum Anchor Clevis	3 Nov 1971	18,846	2.0	1.0	Replaced bent clevis.
NAS 1361 C7C25D Drum Anchor Quick-Release Pin	9 Oct 1974	31,142	4.0	4.0	Replaced bent pin.
513931-1 Drum Anchor Subassembly	9 Oct 1974	31,142	4.0	4.0	Replaced bent subassembly.
611038-2 Bridle Tensioner Pilot Valve	27 Jul 1973	24,158	1.0	1.0	Replaced failed O-ring on end cap.
A92380-19 Idler Gear Roller Bearing	6 May 1971	13,715	16.0	8.0	Outer race spinning in place; secured in place with LOCTITE.
AN6227-45 RRE Piping Port "p" of Manifold O-ring	27 May 1971	15,463	3.0	1.5	O-ring failed at port "p" of manifold assy. Found attaching screws for this flange could be tightened with ordinary hand tools, indicating the required 420-470 ft-lb of torque had decreased considerably.
508459-1 Forward Relief Valve	6 Aug 1971	17,177	1.0	1.0	Relief valve did not relieve--reset to 2,800 psi.

TABLE AIV - TYPE III FAILURES (CONTINUED)

Component (Part No. and Name)	Date of Failure	Catapult Launch No.	Time to Repair Man-Hours	Time to Repair Actual Hours	Description of Failure
VERTICAL ACCUMULATOR					
AN6230-10 Stroke control O-ring	4 Jan 1974	25,292	1.0	1.0	Replaced O-ring because of leakage.
	17 Oct 1974	26,477	3.0	3.0	Replaced O-ring.
	29 Aug 1975	28,831	3.0	1.5	Replaced leaking O-rings.
AN6227-7 Stroke control O-rings	15 Sep 1970	18,292	3.0	1.5	Replaced O-ring because of air leakage.
	23 Nov 1970	18,476	3.0	1.5	"
	15 Jul 1971	19,955	3.0	1.5	"
	20 Sep 1971	20,518	3.0	1.5	"
	1 Dec 1971	21,226	6.0	3.0	Replaced leaking O-ring. Failure caused by worn rod.
	24 Feb 1972	21,810	3.0	3.0	Replaced leaking O-ring.
	26 Apr 1972	21,882	1.0	1.0	"
	18 Jul 1972	22,260	1.0	1.0	"
	8 Aug 1972	22,422	2.0	2.0	"
	20 Sep 1972	22,610	16.0	8.0	"
	15 Nov 1973	24,722	8.0	4.0	"
	8 Apr 1974	25,664	2.0	2.0	"
	17 Oct 1974	26,477	3.0	1.0	"
	29 Aug 1975	28,831	3.0	1.5	"
511469-2 Stroke control actuator arm	17 Oct 1974	26,477	6.0	3.0	Replaced arm.
AN6230-5 Inlet hydraulic piping union O-rings	26 Oct 1972	22,723	8.0	4.0	Replaced leaking O-ring.
	6 Jul 1973	23,021	1.0	0.5	"
AN6230-8 Inlet hydraulic piping union O-rings	24 Sep 1973	23,641	1.0	0.5	"
AN6230-5 Inlet hydraulic piping union O-rings	29 Oct 1973	24,342	1.0	0.5	"
	2 Jan 1974	25,292	1.0	1.0	"
	18 Nov 1974	26,570	0.5	0.5	"
N/A	19 Oct 1972	22,707	32.0	10.0	Replaced vertical accumulator because of excessive leakage of air into hydraulic side of accumulator. Found accumulator wells badly scored. Replaced with space.
CSV (CAPACITY SELECTOR VALVE)					
D4354 Rev 2 1372 C1110 Printed Circuit Board	2 Oct 1970	18,305	1.0	1.0	Replaced malfunctioning board.
Phila. Gear Corp. PN 60-508-0013-3 Hand Wheel	30 Jan 1975	26,714	6.0	3.0	Hand wheel became disengaged from its HSG cap PN 60-122-0024-2 because retaining ring PN RS-275 was missing.
D508722-32 Mode Selector Light Switch	22 Oct 1974	26,477	1.0	1.0	Disassembled and cleaned badly corroded contacts.

TABLE AIV - TYPE III FAILURES (CONTINUED)

Component (Part No. and Name)	Date of Failure	Catapult Launch No.	Time to Repair Man-Hours	Time to Repair Actual Hours	Description of Failure
CSV (CONTINUED)					
614067-4 Monitor Console Readout	23 Nov 1971	21,164	0.5	0.5	Readout malfunctioning; replaced digit numbers.
AN6230-5 Piping Strainer O-rings	25 Apr 1973	22,971	0.5	0.5	Replaced leaking O-rings.
2N3835 Circuit Board A-1 Transistor	10 Oct 1973	24,051	2.0	2.0	Replaced failed transistor.
514680-2 Position Readout on CCP	17 Feb 1972	21,725	1.0	1.0	No. 2 digit would not register; replaced readout.
	10 Oct 1973	24,051	1.0	1.0	Replaced because of malfunction.
ROTO-LAUNCH VALVE					
AN6230-8 Opening Piping O-ring	16 Jun 1975	27,508	0.5	0.5	Replaced leaking O-ring.
AN6230-5 Hydraulic Actuator Piping O-ring	16 Jun 1975	27,508	1.0	1.0	"
AN6230-8 Closing Side Piping O-ring	18 Sep 1973	23,484	0.5	0.5	"
CJB (CENTRAL JUNCTION BOX)					
418403-1 R-2 Relay Light Capsule "LAUNCH VALVE CLOSE" Relay	10 Apr 1974	25,706	1.0	1.0	Relay overheated and was replaced.
CCP (CENTRAL CHARGING PANEL)					
AN6227-12 Auxiliary Pump Hydraulic Pressure Gauge Piping Union O-ring	18 Apr 1974	25,744	0.5	0.5	Replaced leaking O-ring.
B508722-13 No. 1 Hydraulic Pump Light Switch	9 Feb 1976	29,350	1.0	1.0	Knob was broken off.
509165-1 Low-Pressure Air Supply Gauge Valve F/HK	27 Jun 1975	27,954	1.0	1.0	Valve corroded and rusted.
509114-1 Low-Pressure Air Isolation F/HL Globe Valve	18 May 1972	22,007	2.5	2.5	Could not be shut. Rust and corrosion found inside valve.
	15 Jan 1975	26,706	4.0	4.0	
MS28762-0240 Gauge Hose	17 May 1972	21,982	1.0	1.0	Hose deteriorated from rust and sludge.

TABLE AIV - TYPE III FAILURES (CONTINUED)

Component (Part No. and Name)	Date of Failure	Catapult Launch No.	Time to Repair Man-Hours	Time to Repair Actual Hours	Description of Failure
CCP (CONTINUED)					
D89789-2 No. 1 Vickers Pump Gauge	17 May 1972	21,982	1.0	1.0	Gauge not reading. Found tubing to gauge deteriorated from rust and sludge.
Honeywell PN 906 BDH Stroke Control Selector Light Switch Cover Plate	4 Dec 1974	26,583	3.0	1.5	Cover plate broke when replacing lights.
Honeywell PN 910 AEA 011 Stroke Control Switch Operators Selector Indicator	4 Dec 1974	26,583	3.0	1.5	Switch malfunctioned: would not turn pump ON or OFF STROKE.

APPENDIX B - EXCERPTS FROM REPORT NATF-MISC-COS-1: RELIABILITY ANALYSES OF CVN 68 SYSTEMS

I ANALYSIS OF TC13 MOD 1 CATAPULT FAILURE DATA

Failure data of Table BI was classified as either assignable cause or inherent (see reference (d)).

TABLE BI - TC13 MOD 1 CATAPULT FAILURE DATA

Failure No.	$T(\tau i)$	Type	Failure No.	$T(\tau i)$	Type
1	0	Assignable cause	31	3937	Assignable cause
2	0	" "	32	3968	" "
3	4	" "	33	4415	Inherent
4	35	" "	34	4513	"
5	90	" "	35	4586	Assignable cause
6	100	Inherent	36	4623	" "
7	100	Assignable cause	37	4623	Inherent
8	169	Inherent	38	4679	"
9	337	"	39	4700	"
10	574	Assignable cause	40	4704	Assignable cause
11	625	Inherent	41	4971	" "
12	864	Assignable cause	42	4989	" "
13	1171	Inherent	43	5194	" "
14	1588	"	44	5507	" "
15	1688	"	45	5803	" "
16	1693	Assignable cause	46	6021	Inherent
17	1745	" "	47	6809	Assignable cause
18	2149	Inherent	48	6822	Inherent
19	2236	Assignable cause	49	7075	Assignable cause
20	3113	" "	50	7350	Inherent
21	3113	Inherent	51	7809	"
22	3436	Assignable cause	52	7846	Assignable cause
23	3529	Inherent	53	7853	" "
24	3538	"	54	8176	Inherent
25	3594	Assignable cause	55	8185	Assignable cause
26	3622	" "	56	8286	" "
27	3782	" "	57	8358	Inherent
28	3822	" "	58	8762	"
29	3841	Inherent	59	8933	Assignable cause
30	3937	"	60	9168	Inherent

TABLE BI (CONTINUED)

Failure No.	$T(\tau i)$	Type
61	9753	Inherent
62	9753	Assignable cause
63	10617	Inherent
64	10772	"
	11058	No failure: end of test program.

Procedure 6 of reference (f) was used to test whether failure rate in the first half of the life test differed significantly from failure rate in the second half of the life test. Under the null hypothesis of an exponential distribution of life

$$\frac{T(\tau r)}{T(\tau_{2r}-\tau_r)}$$

is distributed as F(2r, 2r). For the Table BI data, equation (1) gives a result of $\frac{3968}{11058-3968} = 0.560$ (for this test it was assumed that failure 64 occurred at $T(\tau_{64}) = 11058$). $F_{.025}(64, 64)$ is approximately 0.610 so that with confidence exceeding 0.975, it can be asserted that failure rate in the second half exceeds that in the first half. Procedure 8 of reference (f) was applied separately to each of the data sections.

Results for $\hat{\theta}$, R(1), R(20), $\theta(.90)$, $R_{.90}(1)$, and $R_{.90}(20)$ were based on 32 failures rather than the values of k used for the procedure 8 test. Results are presented in Table BII.

TABLE BII - RELIABILITY RESULTS FOR TC13 MOD 1 FAILURE DATA

	k	χ^2	$\chi^2_{.10}(k-1)$	$\hat{\theta}$	R(1)	R(20)	$\theta(.90)$	$R_{.90}(1)$	$R_{.90}(20)$
SERVICE LIFE 0 - 3968	27	41.1	35.6	124	.992	.850	101	.990	.819
SERVICE LIFE 3968 - 11058	30	35.9	39.1	222	.995	.913	180	.994	.894

II RELIABILITY OF TC13 MOD 1 WITHOUT REPEATING ASSIGNABLE CAUSE FAILURES

Thirty-four failures in Table BI were classified as assignable cause. These failures can be eliminated by system development to improve reliability. For example, the bridle tensioner solenoid failed 10 times. This is an assignable cause failure which can be eliminated by design improvement. The analysis of this section was conducted by eliminating repeated failures of Table BI.

TABLE BIII - TC13 MOD 1 FAILURE DATA WITHOUT REPEATED ASSIGNABLE CAUSE FAILURES

Failure No.	T(τi)	Type	Failure No.	T(τi)	Type
1	0	Assignable cause	21	4415	Inherent
2	0	" "	22	4513	"
3	100	Inherent	23	4586	Assignable cause
4	100	"	24	4623	Inherent
5	169	"	25	4623	Assignable cause
6	337	"	26	4679	Inherent
7	574	Assignable cause	27	4700	"
8	625	Inherent	28	4971	Assignable cause
9	1171	"	29	4989	" "
10	1588	"	30	6021	Inherent
11	1688	"	31	6822	"
12	2149	"	32	7350	"
13	3113	"	33	7809	"
14	3113	Assignable cause	34	8176	"
15	3529	Inherent	35	8358	"
16	3538	"	36	8762	"
17	3782	Assignable cause	37	9168	"
18	3841	Inherent	38	9753	"
19	3937	"	39	10617	"
20	3968	Assignable cause	40	10772	"
				11058	*No failure: end of test program.*

The Barlow-Scheuer Reliability Growth Procedure (see references (d) and (g)) was used to combine the data of Table BIII into development stages (see Table BIV on the following page).

TABLE BIV - INITIAL COMBINATION OF TC13 MOD 1 DEVELOPMENT STAGES

Stage i	Inherent Failures a_i	Assignable Cause Failures b_i	Successes c_i	Trials $a_i + b_i + c_i$	$\frac{b_i}{b_i + c_i}$
1	0	2	0	2	1
2	4	1	569	574	1/570
3	6	1	2532	2539	1/2533
4	2	1	666	669	1/667
5	2	1	183	186	1/184
6	2	1	615	618	1/616
7	1	1	35	37	1/36
8	2	1	345	348	1/346
9	0	1	17	18	1/18
10	11	0	6058	6069	0
TOTALS	30	10	11020	11060	-

The only way in which $\frac{b_i}{b_i+c_i} > \frac{b_{i+1}}{b_{i+1}+c_{i+1}}$ for all i was to combine stages 1 - 3 and 4 - 10. This final combination of stages is shown in Table BV.

TABLE BV - FINAL COMBINATION OF TC13 MOD 1 DEVELOPMENT STAGES

Stage i	Inherent Failures a_i	Assignable Cause Failures b_i	Successes c_i	Trials $a_i + b_i + c_i$	$\frac{b_i}{b_i + c_i}$
1 Service Life 0-3113	10	4	3101	3115	4/3105= .001288
2 Service Life 3113-11058	20	6	7919	7945	6/7925= .000757
TOTALS	30	10	11020	11060	-

The reliability analysis for the two development stages is presented in Table BVI on the following page.

TABLE BVI - RELIABILITY RESULTS FOR TC13 MOD 1 WITHOUT REPEATING ASSIGNABLE CAUSE FAILURES

	k	χ^2	$\chi^2_{.10}(k-1)$	$\hat{\theta}$	R(1)	R(20)	$\theta(.90)$	$R_{.90}(1)$	$R_{.90}(20)$
SERVICE LIFE 0 - 3113	10	6.93	14.68	223	.996	.914	164	.994	.885
SERVICE LIFE 3113 - 11058	26	27.0	34.4	307	.997	.937	243	.996	.921

APPENDIX C - NAVAIRTESTFAC DISCREPANCY REPORTS (BLUE SHEETS) APPLICABLE TO CVN 68/CVN 69 LAUNCHING SYSTEM - ICCS

NAVAIRTESTFAC Blue Sheet		NAVAIRENGCEN	
No. and Date	Discrepancy and Action Taken	Date	Action/Reply
TC13-1-127 12 Jan 72	Catapult operations using Emergency Mode I (control at emergency deck-edge panel with catapult officer on deck) have shown that the catapult status signals from deck-edge operator are inadequate as a replacement for deck auxiliary panel. Operating personnel feel that the indication of catapult status through the deck auxiliary panel would also be advantageous during normal operations from the ICCS.	18 Jan 1972	1. Auxiliary panels on present ships are provided for catapult officer's convenience. With the ICCS, catapult officer has all necessary info in front of him on his console. Deck crew does not need the lights. It is doubtful whether they can be seen at the required distances on CVN 68 on sunny days. A high-intensity flashing SUSPEND light was provided for deck crew to alert them during suspend or hangfire conditions. 2. The benefit during Emergency Mode I is apparent because of similarity with existing carrier operations. Auxiliary panel was left off CVN 68 because it was felt Emergency Mode I would be used infrequently and added expense could not be justified, considering that Emergency Mode I would be a very slow operation relying on hand signals and voice communication. 3. However, due to strong recommendations of operating people NAEC concurs with recommendations. A program will be established for addition of auxiliary panel in CVN 68 system. T&E at NATF will precede shipboard installation. 4. Since normal ICCS operations do not require this panel, it will be put in a service-change category.

NAVAIRTESTFAC Blue Sheet		NAVAIRENGCEN	
No. and Date	Discrepancy and Action Taken	Date	Action/Reply
TC13-1-159 15 Jan 74	Panel, 613958-1, supplied with Change 182 did not have cutouts for MADIS erase switch. Existing and future Change kits should be checked to insure panel is manufactured to print. Flathead mounting bolts for position indicator, 416586-1, form an objectionable protrusion when used to fill existing mounting bolt holes. Panhead bolts should be supplied with Change to fill existing position-indicator mounting bolt holes. *Action Taken:* Switch cutouts were installed in accord with REV E of 613458-1 print and panhead bolts were used to fill position-indicator mounting bolt holes.	28 Jan 1974	Appropriate steps will be taken to ensure properly manufactured panel. Service Change document will be revised to incorporate panhead screws.
TC13-1-164 10 May 74	a. Transfer switch installation in charging panel interfered with closing front panel door. Access to electrical connector in back of transfer switch was limited by existing pressure switch mounting bracket and pressure switches. b. Mounting bolt holes in PN 421426 mounting plate did not match mating holes in PN 421475 angle brackets when parts installed in cabinet. c. Transfer switch assembly PN 617891 delivered with normal contacts jumper-wired together which prevented transferring deck panel out of system (Ref wiring assy PN 617888). d. CJB wiring changes of EO 72-291 do not provide a power supply for transfer switch legend lights. e. Deck panel signal box assy PN 31-50445 provides 2 bulbs for each indicator. Installation appears to indicate only 1 bulb is connected. Print should be made clearer.	20 May 1974	Engineering concurs with recommendations. Drawings will be changed so that mounting will be compatible with varying dimensions of enclosures. Jumper wires were inadvertently installed in electrical connector of transfer switch assy; NAEC dwgs do not reflect this error. Rotary switch supplied with EO 72-291 is inadequate to supply power to transfer switch indicator light; Engineering will revise EO to supply 10-position rotary switch. Auxiliary deck edge panel is wired in accord with elec sys installation for CVA 41 CVA 67. No illumination difficulties reported to Engineering. Light bulbs can be parallel wired to determine intensity needed for day/night operations. NAEC drawings will be revised as required to incorporate these changes.

NAVAIRTESTFAC Blue Sheet		NAVAIRENGCEN	
No. and Date	Discrepancy and Action Taken	Date	Action/Reply
TC13-1-167 15 Jan 75	Safety cover hinge of catapult officer's console FIRE push-button switch failed after 600 events. Hinge pin did not come out of place. Similar failures occurred on CVN 68 consoles. Hinge restricts cover to 90 deg of movement, imparting an excessive load on hinge at limit of travel. Cover design should be changed to provide 180-deg cover rotating allowing cover to lay flat against console face when opened fully; this was done on catapult officer's console FIRE switch.	24 Jan 1975	Request made to vendor 6 Jan 1975 to investigate redesign to reliable 180° opening on a mass production basis. Pending successful investigation, corrective action will be taken to incorporate approved design into CVN 68 and other affected areas.
TC13-1-172 17 Oct 75	Corrosion of negative battery contacts in radio set helmet and battery charger is causing frequent equipment malfunctions and abnormally high maintenance actions. Naval Electronics Systems Command should be informed of the problem and corrective action be taken to eliminate this corrosion. *Action Taken:* Gold plating of contacts to eliminate corrosion is being investigated.		None.

APPENDIX D - NAVAIRTESTFAC DISCREPANCY REPORTS (BLUE SHEETS) APPLICABLE TO CVN 68/CVN 69 LAUNCHING SYSTEM - ROTARY RETRACTION ENGINE

NAVAIRTESTFAC Blue Sheet		NAVAIRENGCEN	
No. and Date	Discrepancy and Action Taken	Date	Action/Reply
TC13-1-161 28 Mar 74	On NATF retract directional valve (SN 2-32), spring pin hole shown in detail "D" of directional valve operator assy DWG 616712 REV B does not extend through the shaft (PN 514513-1) and piston spool (PN 511959-1). Spring pin (PN MS9048-240) was installed in a blind hole. Survey all existing large operator valves and those scheduled for installation in accordance with C13 Mod 1 Design Change 245 to determine if a similar problem exists. *Action Taken:* Retract valve SN 2-32 was modified by drilling a through-hole in accordance with detail "D" of DWG 616712 REV B and installing the correct spring pin.	16 Apr 1974	Concur with recommendation. If discrepancy exists, repair in same manner. A copy of this report will be sent to QA for action.
TC13-1-162 28 Mar 74	The setscrew (PN MS51033-252) that retains operator sleeve (PN 419963-1) to shaft (PN 514513-1) was found loose on both advance and retract directional valves, which permitted sleeve to unscrew from shaft, resulting in a change of piston stroke. Revise DWG 616712 REV B to show more positive means of positioning setscrew. Survey all existing large operator valves and those scheduled to be incorporated in accord with subject Design Change. Be more specific as to class of thread being tapped in sleeve in detail E of DWG 616712 REV B. *Action Taken:* A detent was drilled in both advance and retract valve shafts, PN 514513-1, as a more positive means of positioning the set screw. In addition, Locktite was used on setscrew threads.	23 Apr 1974	a. Detent shall not be drilled in shaft while sleeve is on shaft. Valve shall be assembled to insure proper stroke. Shaft should be marked templating from tapped hole in sleeve. Remove sleeve and drill hole in shaft. Reassemble per DWG using Locktite on setscrew threads. Our DWG will be revised to reflect this change. b. Request QA survey all existing valves. c. Class of thread being tapped in sleeve is clearly defined on sleeve DWG 419963 as #10-32UNF-3B.

NAVAIRTESTFAC Blue Sheet		NAVAIRENGCEN	
No. and Date	Discrepancy and Action Taken	Date	Action/Reply
TC13-1-166 25 Jul 74	CATAPULT READY status light was obtained even though catapult was suspended. RRE FULL AFT limit switch wiring connection had broken and rotated such that one of the broken wires touched an unused pin to complete the electrical circuit, giving a false CATAPULT READY light. The shipboard-type cable wiring is too large for the small pin connections on the microswitch plug, making it almost impossible to obtain a proper soldered joint. This discrepancy is also reported in enclosure (1) (NAEC Field Technical Report 145-74 CVA 66/C13,C13-1 of 26 Jun 1974) in a similar situation. After wires are soldered to pin connections, a potting compound should be used to prevent the wires from rotating and touching the unused pins in the plug. Enclosure (1) recommends the plug be vulcanized to the cable. *Action Taken:* A new switch was installed and the wires resoldered on the proper pin connections as carefully as possible.		None.
TC13-1-175 29 Mar 76	The radial-thrust assembly-group, PN 101847, consisting of 5 pieces (radial race, PN 66119; box thrust race, PN 49037; thrust roller group, 101846; radial roller group, 101845; and socket thrust race, PN 49038) is unacceptable. The parts were not marked individually other than the identification on the packaging. Therefore, the manufacturer's word must be taken that the redesigned improved radial thrust assembly is in fact made of superior materials. In fact, when the materials were received from BRASO, metal shavings were found in the box and the edges of the bearing assembly were gouged. Since the manufacturer will not release adequate drawings to inspect these parts, only a visual inspection could be made. Manufacturer should identify each of the five pieces making up the radial thrust assembly to insure the materials are the new improved assembly. *Action Taken:* Materials were accepted by NAEC Engineering and are being installed in the hydraulic motor.	12 May 1976	NAEC contacted vendor to recommend each component part of bearing group be identified. Vendor will comply.

APPENDIX E - NAVAIRTESTFAC DISCREPANCY REPORTS (BLUE SHEETS) APPLICABLE TO CVN 68/CVN 69 LAUNCHING SYSTEM - MARK 4 CRO BRIDLE ARRESTER

NAVAIRTESTFAC Blue Sheet		NAVAIRENGCEN	
No. and Date	Discrepancy and Action Taken	Date	Action/Reply
TC13-1-132 12 Apr 72	The electrical and air lines which control the deflector assemblies do not have trough-cover-to-trough-exterior interface quick-disconnects. An electrical quick-disconnect is required by DWG 617307 but the disconnect permits the loose wire to hang outside of the trough. The air hoses are connected directly to the solenoid valve. *Action Taken:* a. A manifold block and service-station-type quick-disconnects were installed in each trough cover to ease the removal of each cover. b. The electrical disconnect was relocated so that the disconnect takes place at the trough cover similar to the present chronograph installation (DWG 615298).	20 Apr 1972	Data and photographs have been requested on these items. Drawing will be modified accordingly upon receipt of this information.
TC13-1-135 17 Apr 72	The square corners of the housing assemblies and deck cover plates require that square-cornered cavities be machined into each trough cover. Much time-consuming work may be saved by rounding or beveling each corner of these units to permit rounded corners to be machined into the trough-cover cavities. *Action Taken:* One-half-inch radii were machined on each of the housings' and plates' corners to match the one-inch-diameter cutter radii which were machined into the trough-cover cavities.		None.
TC13-1-138 15 Aug 72	After 3 different bridle no-load launchings the bridle or pendant hung up during bridle retraction between the aft end of the deflectors and forward portion of the shuttle throat because of a gap between these parts. Gap was caused by piston assy rebound out of water brakes. In above cases, piston assy was not returned as usual by the advancing grab to full bottomed position in water brakes because automatic advance was not actuated due to insufficient cylinder pressure after the no-load launching to energize end-of-run switch.	4 Oct 1972	NAEC records indicate discrepancy occurred when TC13-1 was jury-rigged to simulate a short catapult (C7). This jury-rigging did not positively keep shuttle fully seated in water brake because there was insufficient residual steam pressure in the catapult cylinders. As this discrepancy was caused by unusual, nonstandard test configuration which will not occur during normal shipboard ops, no further action is necessary.

NAVAIRTESTFAC Blue Sheet		NAVAIRENGCEN	
No. and Date	Discrepancy and Action Taken	Date	Action/Reply
TC13-1-165 30 May 74	During recent bridle arrester operations, bridle deflectors failed to raise when actuated because: position of link (PN 420076), arm (PN 420075), and piston rod knuckle (PN 419858) when deflector is in down position, is such that the mechanical advantage is marginal for raising motion to begin. Situation is aggravated by inability to lubricate actuating linkage when deflectors are in place. Also, deflector ramps (PN 514628) were nicked and abraded by bridle during retraction, causing interference between ramp and housing, which also impeded raising motion. *Action Taken:* Deflector assemblies were removed and lubricated to minimize linkage friction. Outboard edge of deflector ramps were filed to eliminate interference between ramp and housing. During retraction the deflector blades must be given a manual assist at the start of raising.	17 Jun 1974	On 7 and 12 Jun, NAEC Rep, Mr. K Hoffman, visited NATF site and witnessed that port deflector would raise and stbd wouldn't. On the bench both units performed satisfactorily; however, the same problem recurred when reinstalled on the site. This could indicate that air supply is the trouble. Further tests have been outlined by Mr. Hoffman to isolate the cause. Tests will be conducted when site is available.

APPENDIX F - NAVAIRTESTFAC DISCREPANCY REPORTS (BLUE SHEETS) APPLICABLE TO CVN 68/CVN 69 LAUNCHING SYSTEM - VERTICAL ACCUMULATOR

NAVAIRTESTFAC Blue Sheet		NAVAIRENGCEN	
No. and Date	Discrepancy and Action Taken	Date	Action/Reply
TC13-1-140 17 Oct 72	Main hydraulic accumulator piston O-rings (3) replaced because of leakage. O-rings stretched excessively, approx 3-7 inches on circumference, and 2 lower rings showed worst condition. The 2 lower rings had severe surface blisters. O-rings were in use 7,416 launchings and 18,725 RRE events over a period of 39 months. *Action Taken:* New O-rings of same type were installed on the piston.	7 Nov 1972	Problem being looked into per EO 72-514. O-ring material specified on dwg is compatible with hyd fluid. The 2 lower O-rings (on air side) showed worst condition. Heat from working the air plus heat from friction of O-ring rubbing on dry cylinder wall are possible causes of this failure.

APPENDIX G - NAVAIRTESTFAC DISCREPANCY REPORTS (BLUE SHEETS) APPLICABLE TO CVN 68/CVN 69 LAUNCHING SYSTEM - CAPACITY SELECTOR VALVE

NAVAIRTESTFAC Blue Sheet		NAVAIRENGCEN	
No. and Date	Discrepancy and Action Taken	Date	Action/Reply
TC13-1-129 28 Jan 72	CSV mechanical counter, PN 614958-3, failed on 20 Jan 1972, after launch 21,452. Drive shaft within the counter housing failed ~~in~~ in apparent pure torsion. Counter accumulated 16,335 launches; does not include many launch valve cycles or numerous other cycles on CSV valve. *Action Taken:* Operations continuing without mechanical counter until a new shaft is procured.	3 Feb 1972	a. This problem has been investigated. The result is that costs for a redesigned, stronger counter would be 5-10 times that of existing counters, since procurement is of low quantity. Spare counters are provided; since failure rate is low, it is cheaper to replace defective counter with a new one of identical design. b. This problem has previously been placed on the NAEC Problem Investigation List and answered as above. Action is considered completed.

APPENDIX H - NAVAIRTESTFAC DISCREPANCY REPORTS (BLUE SHEETS) APPLICABLE TO CVN 68/CVN 69 LAUNCHING SYSTEM - CENTRAL CHARGING PANEL

NAVAIRTESTFAC Blue Sheet		NAVAIRENGCEN	
No. and Date	Discrepancy and Action Taken	Date	Action/Reply
TC13-1-104 23 Nov 71	Two 0-3,000 psi gauges for the main hydraulic Vickers pump failed on the CCP. In one instance, Bourdon tube ruptured, and in other, tubing from Bourdon tube split open. Both failures can be attributed to the fact that the relief valve settings were increased from 2,700 ±50 psi to 3,000 ±50 psi in order to conform to CVN 68 shipboard procedure delineated in report NAEC-ENG-7430, and operating range of gauge is only 0-3,000 psi.	2 Dec 1971	NAEC Test Engineer discussed failures with NATF site personnel; they stated that gages failed in summer of 1971. These gages failed prior to changing pump relief valve setting from 2,700 ±50 psi to 3,000 ±50 psi. The probable cause was that gage snubbers were not set up properly. Normal operating pressure is 2,500 ±50 psi. The gages would only see 3,000 psi during relief valve setting procedures and if stroke control switches or solenoid valve failed, and even then the gages would not be damaged. No action should be taken to replace 0-3,000 psi gages with 0-5,000 psi gages unless additional failures occur.
TC13-1-116 8 Dec 71	CCP operator's ability to monitor operations and troubleshoot problems is restrictive because the charging panel status and malfunction lights are not all active during normal operations. Also, he has no direct indication when the catapult is suspended from another station. With the work load and divided attention of the monitor, the CCP operator should be provided with the optimum ability to monitor operations. All CCP malfunction lights and status lights should be active during all modes of operation. Also, a remote suspend light should be provided on the CCP--a single light tied into all stations would be sufficient.		None.

NAVAIRTESTFAC Blue Sheet		NAVAIRENGCEN	
No. and Date	Discrepancy and Action Taken	Date	Action/Reply
TC13-1-134 13 Apr 72	Gauge valves on CVN 68 CCP for medium pressure air (F/EF), bridle tensioner dome air (F/CO), the bridle tensioner accumulator air (F/AM), and the retraction engine accumulator air (F/CK) are so badly corroded internally with rust that they cannot be closed. The valves are frozen in the open position. The handle of one of the valves (F/EF) was broken off while attempting to close it. Replace valves with stainless-steel valves.		NOTE: Original blue sheet was lost. Service Change C13/C13 Mod 1 290/220 was prepared and is awaiting NI notification for issue.
TC13-1-158 11 Jan 74	Steam-equipment support plate at rear of CCP could not be modified in accordance with NAEC DWG 516584 of C13 Mod 1 Design Change 256. Reference dimension, 9-5/8 inches, is actually 10-3/8 inches on the plate. If the 9-5/8-inch dimension is used, the through-holes for the mounting bolts would be removed when the cutout is made. *Action Taken:* The plate cutout was made as follows: a. The 8-1/4-inch dimension was changed to 8-3/4 inches to include through-hole for the mounting bolts. b. The cutout portion was reduced from 4-3/8 inches to 3-7/8 inches because of the above dimensional change.	21 Jan 1974	Concur with recommendations. Drawing has been revised and subject Design Change will be amended.
TC13-1-168 5 Mar 75	1. Light switch selector knobs have low service life of six months or less. Initial failure occurs when knob position indicating arrow segment falls out, eliminating the rigidity of the remaining thin plastic cylinder so weakened, the remainder of the knob soon fails, rendering the switch useless. 2. Selector knob replacement requires replacement of the operator indicator which in turn requires removal of entire switch assembly from rear of panel. Front end removal is not possible due to the switch wiring method. 3. Service life of light switch cover plates is also low. These plates must be removed to replace light bulbs and fail at the retaining clip area. When the retaining clips fail, little foreign matter protection is available and light-bulb function is intermittent if at all.	12 Mar 1975	Information noted and will be added to the NAEC Problem Investigation List.

APPENDIX I - NAVAIRTESTFAC DISCREPANCY REPORTS (BLUE SHEETS) APPLICABLE TO CVN 68/CVN 69 LAUNCHING SYSTEM - DESI

NAVAIRTESTFAC Blue Sheet		NAVAIRENGCEN	
No. and Date	Discrepancy and Action Taken	Date	Action/Reply
TC13-1-141 29 Nov 72	Recent sensor failures on TC13 Mod 1 catapult have been caused by a broken wire at the sensor plug, probably caused by vibration. A longer wire shaped as a coil to connect sensor circuitry to sensor plug should be employed. A rubber gasket should also be inserted between sensor plug and housing for moisture protection. *Action Taken:* Repaired broken wire in sensor or replaced sensor.	7 Dec 1972	DESI sensor contains an epoxy encapsulated coil and a wire which connects the coil to the sensor plug. The latter wire forms a coil when sensor plug is mounted to sensor housing. DESI sensor dwg has been revised to require shrink tubing surrounding the joint between wire and sensor plug. Cavity behind sensor plug where coil of wire is located will be potted. This will reduce effects of vibration. Gasket between sensor plug and housing not required with new sensor design. Moisture cannot penetrate potting behind plug.

APPENDIX J - NAVAIRTESTFAC DISCREPANCY REPORTS (BLUE SHEETS) APPLICABLE TO CVN 68/CVN 69 LAUNCHING SYSTEM - AUTOMATIC JET BLAST DEFLECTOR

NAVAIRTESTFAC Blue Sheet		NAVAIRENGCEN	
No. and Date	Discrepancy and Action Taken	Date	Action/Reply
TC13-1-125 9 Dec 71	Present electrical system of auto JBD is not fail-safe. Design of system allows JBD to raise when catapult is in "cat ready" status and FDNGL buffer is buffered aft. Modify electrical drawings to include fail-safe feature and include this item on NAEC Problem Investigation List. *Action Taken:* NAEC has been notified and is revising the electrical system.	3 Jan 1972	EO 71-685 REV D is issued ordering material for fail-safe condition. NAEC DWG 617398 REV B and 617399 REV A are issued covering mechanical and electrical requirements. DWG 616659 and 616660 will not be revised at present, but will be modifed by DWG 617399 REV A. This item is in design/test stage of development and should not be added to NAEC Problem Investigation List.
TC13-1-156 4 Oct 73	With JBD in auto controls, JBD panel does not lower automatically as intended upon actuation of LAUNCH COMPLETE pressure switch if NGL buffer has returned to its BATTERY position prior to firing catapult. JBD LOWER solenoid energizes when LAUNCH COMPLETE pressure switch is actuated; however, the JBD RAISE solenoid does not de-energize which subsequently causes the LOWER solenoid to burn out. JBD RAISE solenoid did not de-energize because the NGL buffer had retracted before the catapult LAUNCH COMPLETE pressure switch was actuated. This situation can occur whenever the buffer retracts prior to catapult LAUNCH COMPLETE--such as during malfunction of LAUNCH COMPLETE pressure switch. *Action Taken:* NATF modified electrical system (617399) so that track switch malfunction relay (R85) energizes through a set of normally-closed contacts of the JBD RAISE relay (R80D); therefore relay R85 cannot be re-energized through the NGL track switch. Even if the NGL buffer has retracted, the JBD track switch malfunction relay (R85) will de-energize and thus permit the RAISE relay (R80) also to de-energize when the holding current to relay R85 is broken.	19 Oct 1973	Corrective action taken is satisfactory and will be incorporated on NAEC DWG 617399 REV D.

NAVAIRTESTFAC Blue Sheet		NAVAIRENGCEN	
No. and Date	Discrepancy and Action Taken	Date	Action/Reply
TC13-1-160 17 Jan 74	If NGL buffer is out of its BATTERY position (JBD actuation switch (S992) uncovered), the JBD does not lower in the automatic mode until the exhaust valve has opened following the launch. This results in a delay in JBD lowering of from 2.2 to 2.7 seconds after the LAUNCH COMPLETE pressure switch has been actuated. *Action Taken:* NAEC has been advised and has revised the electrical system to correct the problem per DWG 617399 REV E. (This report is for record purposes only.)	24 Jan 1974	DWG 617399 has been revised by REV E and will be included in the shipboard installation.

LIST OF ABBREVIATIONS AND NOMENCLATURES

Abbreviation	Nomenclature
CCP	Central charging panel
CJB	Central electrical junction box
CRO	Constant runout
CRS	Central recording station
CSV	Capacity selector valve
DESI	Digital end-speed indicator
FDNGL	Flush-deck nose-gear launch
ICCS	Integrated catapult control station
JBD	Jet blast deflector
LLLV	Low-loss launching valve
MADIS	Manual aircraft data input system
MCBF	Mean cycles before failure
MTTR	Mean time to repair
NAVAIRENGCEN	Naval Air Engineering Center
NAVAIRSYSCOM	Naval Air Systems Command
NAVAIRTESTCEN	Naval Air Test Center
NAVAIRTESTFAC	Naval Air Test Facility*
RRE	Rotary retraction engine
TDP	Technical Development Plan

* Presently the Test Department of the NAVAIRENGCEN.

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