REPORT BY THE U.S.

General Accounting Office

Naval Aircraft Accidents During Launch And Recovery Operations

Over the past 5-1/2 years, the Navy has had 730 aircraft accidents resulting in substantial aircraft damage, aircraft losses, and some crew fatalities. Not all these accidents occurred during carrier operations, and only 29 were associated with launch or recovery phases of carrier air operations. Those associated with carrier air operations have been attributed to one or more of the following:

- Defects in equipment including catapult and arresting-gear equipment.
- Human error by aircraft crewmembers or equipment operators aboard the carriers.

This report provides Navy aircraft accident statistics and information on some of the actions the Navy has taken to improve safety in carrier air operations.

Some of the problems, and the Navy's initiatives aimed at correcting them, are discussed in the report.

LCD-79-432
SEPTEMBER 24, 1979

UNITED STATES GENERAL ACCOUNTING OFFICE
WASHINGTON, D.C. 20548

LOGISTICS AND COMMUNICATIONS DIVISION

B-195780

The Honorable Les Aspin
House of Representatives

Dear Mr. Aspin:

In an April 18, 1979, letter, you asked us to investigate a series of naval airplane crashes that have occurred over the past year or so. You said that there is reason to believe that some of these crashes were caused by defects in the catapult and arresting-gear equipment. We have reviewed the information provided by your office and have held discussions with and reviewed documents provided by Navy officials.

Several of the accidents are currently in various stages of litigation. As discussed with your office, it is our policy not to decide issues that are pending in judicial proceedings. Since the parameters of this work are inseparable from the issues pending in the courts, it is appropriate here that we follow that policy. As your office agreed, we have not delved into areas that we feel the courts may in any way duplicate or preempt. In the absence of doing any work that may encroach upon actions in litigation, it was agreed that we would provide Navy airplane accident statistics and information on some of the actions the Navy has taken to enhance safety in carrier air operations.

As shown in appendix I, 730 accidents have occurred over the past 5-1/2 years. These accidents have resulted in substantial aircraft damage, aircraft losses, and some of them have resulted in crew fatalities.

Not all accidents occurred during carrier operations, and only 29 of these accidents (see app. II) were associated with launch and recovery phases of carrier air operations. Those associated with carrier air operations have been attributed to one or more of the following:

--Capacity selector valve system malfunction.

--Aircraft nose gear launch bar misalinement.

--Damaged and/or inoperable arresting gear.

--Human error by aircraft crewmembers or equipment operators aboard the carriers.

A recent Naval Material Command management review of aircraft carrier catapult and arresting-gear operations identified some problems and causes associated with airplane crashes during the launch and recovery phases of aircraft carrier operations. As agreed with your office, we are enclosing a copy of that review (see app. III). Some of the problems, and the Navy's initiatives aimed at correcting them, are discussed in the following sections.

CAPACITY SELECTOR VALVE

The capacity selector valve is a major component which regulates the steam pressure required to operate the catapult equipment. The valve was first put into use in 1968 and has subsequently gone through several modifications. The capacity selector valve has been perceived and criticized as a major contributor to several airplane accidents.

The most serious problems with the capacity selector valve system have been identified in its electronic system. In spite of the problems, the Navy had confidence in the electronic system because of its built-in safety feature. The system was designed to prevent automatic aircraft launch when there is a malfunction. There were also operator instructions to suspend launch procedures whenever there were indications of a malfunction. Because the Navy relied on the built-in safety feature and had reasonable assurance that trained operators would follow established operating instructions, there was no urgent compulsion to do anything other than repair or replace malfunctioning items.

After approximately 9 years of operation, a malfunction to the capacity selector valve system caused the loss of an aircraft and crew. To eliminate future accidents, the Navy installed a redundant system and issued additional operator instructions.

To complement the redundant system, the Navy has designed a new electrical system. This system is currently being tested at the Naval Air Engineering Center. Center officials stated that the testing has been successful.

NOSE GEAR LAUNCH BAR

The launch bar is a part of the aircraft. It is designed to interface with the carrier's shuttle mechanism which propels the aircraft during launch. When the shuttle and launch bar are not alined or properly seated, the launch bar is designed to separate from the shuttle mechanism in the launch preparatory stage, preventing launch from taking place.

In September 1978, for the first time, the two mechanisms, improperly seated, did not separate until the aircraft was in the launching process. After an analysis of the accident and a series of tests, the Naval Air Engineering Center could not duplicate the circumstances which caused the accident. To reduce the possibility of a recurrence, the Navy modified the equipment and installed wheel guides on the carrier decks to ensure proper alinement of the shuttle mechanism and the launch bar and reemphasized the operator instructions to inspect the launch bar/shuttle before launching the aircraft.

DAMAGED AND/OR INOPERABLE
ARRESTING GEAR

The arresting gear is a series of four cables, one of which the aircraft engages upon landing. These cables, commonly referred to as cross deck pendants, are retracted after the aircraft has been recovered by being dragged along the flight deck and catapult slots. This causes abrasions and weakens the structure of the cable. Tests substantiate that cables which fall in the catapult slot receive heavy abrasions when retracted. Navy officials state this problem did not surface until March 1978, at which time new operating and inspection procedures were established. In the meantime, obstructions were installed in the catapult slots to prohibit the cable's entry during retraction. Navy officials state that tests of the obstructions have been successful. Other possible solutions are also being developed.

HUMAN JUDGMENT

According to Navy offiçals, it is not practical to design a system(s) that is totally automatic. The catapult and arresting-gear systems were designed to be operated manually if necessary. The capacity selector valve system, for example, is designed with features to alert the operators when there are indications that the system is malfunctioning or is not performing as expected. This requires that operators intercede and either suspend operation or override the system and launch the aircraft. The Navy has determined that these crucial decisions require the mature judgment of the commanding officer and have revised operating instructions to that effect.

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We hope this response satisfies your request. Please advise us if we can be of further assistance on this matter.

Sincerely yours,

Donald J. Horan

for R. W. Gutmann
Director

NAVY AIRCRAFT ACCIDENT STATISTICS

1974 - 1979

Year	Number of aircraft accidents Destroyed	Damaged	Total	Number of fatalities	Aircraft replacement/ repair cost
					(000 omitted)
1974	103	44	147	81	$ 220,450
1975	91	46	137	67	264,571
1976	85	43	128	73	263,675
1977	101	32	133	118	317,787
1978	101	32	133	128	409,267
1979 (Jan.-June)	31	21	52	32	86,778
Total	512	218	730	499	$1,562,528

LAUNCH AND RECOVERY PHASE ACCIDENTS

1974 - 1978

Year	Number of accidents: Aircraft destroyed	Number of accidents: Aircraft substantially damaged	Number of accidents: Total	Replacement cost	Aircraft repair cost	Total cost
				---------(000 omitted)--------		
1974	4	1	5	$ 8,414	$ 134	$ 8,548
1975	6	2	8	33,519	731	34,250
1976	3	2	5	6,320	701	7,021
1977	4	0	4	17,942	0	17,942
1978	7	0	7	46,661	0	46,661
Total	24	5	29	$112,856	$1,566	$114,422

REVIEW

OF

MANAGEMENT

OF

AIRCRAFT CARRIER

CATAPULT AND ARRESTING GEAR

REPORT SUBMITTED

BY

RADM C. C. SMITH, JR., USN

AND

MR. E. M. RYAN

7 FEBRUARY 1979

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REVIEW OF MANAGEMENT OF AIRCRAFT CARRIER CATAPULT AND ARRESTING GEAR

I

INTRODUCTION

1. OVERVIEW. Pursuant to Chief of Naval Material letter of 22 January 1979, appointing Rear Admiral C. C. Smith, Jr., USN (OP-55) and Mr. E. M. Ryan (AIR-510B), a review was conducted, within the Naval Material Command, of the management of the design, development, test and evaluation, production installation and certification of catapults and arresting gear aboard aircraft carriers. A review team was formed and the composition, schedule and plan was reported in OP-55 letter of 1 February 1979. The team met on 24 and 25 January in OPNAV with NAVAIR personnel of the Ships Installations Division (AIR-537) to review NAVAIR management procedures. Areas addressed included NAVAIR organization and management responsibilities, and utilization of the Naval Air Engineering Center (NAEC) at NAS Lakehurst as the engineering development and test organization for the equipment. A discussion of the history of the organizational and technical relationships between NAVAIR and NAEC included NAEC Shore Establishment Realignments (SER) impact, the transfer of some technical responsibilities from NAVAIR to NAEC and the recent consolidation of the former Naval Air Test Facility (NATF), NAEC and NAS Lakehurst into a single command located at Lakehurst. The team visited NAS Lakehurst on 29 and 30 January for an on site review of the internal NAEC organization, responsibilities and functional inter-relationships. NAEC presented a detailed review of several recent problems including those incidents involving the capacity selector valve (CSV), the nose gear launch spreader, cross-deck-pendant/CAT slot interaction problem, and the arresting gear flow control valve flange problem. Each of these problems were traced through the decision making chain from discovery through promulgation of interim or permanent service change solutions. In tracking the decision process, the following subjects were reviewed in depth: preventive and corrective maintenance documentation and publications; maintenance and operating personnel training, qualification and certification; the discrepancy reporting (feedback) system and data collection; and, service change design/redesign procedures. A verbal preliminary report was made to Chief of Naval Material on 1 February 1979.

2. SCOPE. The scope of the review remained within the Naval Material Command management organization with emphasis upon NAVAIR 537 and NAEC as the prime decision makers involving catapult and arresting gear aboard aircraft carriers. A brief tour of the NATTC Aviation Boatswain (AB) training facility at NAS Lakehurst provided a conceptual foundation for evaluation of the management responsibilities of NAVAIR/NAEC in the area of training.

3. APPROACH. The approach to the tasking included the gathering of instructions, reports, messages and other communications from among the principal organizational elements within NAVAIR and NAEC. Briefings and discussions were conducted with leadership and managerial personnel from NAVAIR and NAEC which included CAPT D. W. Rice, USN (AIR-537), MR. R. C. Mahaffey (AIR-5372); CAPT J. H. Hoganson, USN, (CO, NAEC); CAPT F. B. Boice, USN (NAEC-91); CAPT R. L. Williamson (XO, NAEC); Mr. W. J. Cox (NAEC-09); Mr. C. DiBiase (NAEC-91A); LCDR W. R. MacDonald (NAEC-94); Mr. B. F. Kolacz (NAEC-94A).

a. The approach included a review of the overall management process from problem discovery through design development and installation of interim and permanent service changes. The problems and subsequent solutions associated with the capacity selector valve (CSV), the nose gear launch spreader (SPREADER), cross deck pendant/catapult slot interaction (CDP/CAT SLOT), and the arresting gear flow control valve flange (flow valve) were chosen as representative models to track the decision making chain through the problem solving management process.

II

ORGANIZATION

1. NAVAL AIR SYSTEMS COMMAND (NAVAIR)

a. SHIPS INSTALLATION (SI) DIVISION (AIR-537). The organization within the Naval Air Systems Command, as identified in NAVAIRINST 5400.1A (with change 5 of 8 June 1976), establishes the "...Ship Installation Division (AIR 537) directly responsible to the Assistant Commander for Material Acquisition (AIR-05) for all technical activities and administrative matters within the cognizance of the SI Division..." which includes the following responsibilities relative to catapult and arresting gear aboard aircraft carriers:

- plan and implement applied supporting research, development, test, evaluation, arrangement and engineering improvements;
- production, procurement, distribution operation, maintenance and training;
- manage the Integrated Logistics Systems (ILS) program for all material acquisition functions from inception throughout service life for aircraft launch and recovery systems;
- certification of safety and operability aboard carriers to ensure compatibility of aircraft and installations;
- prepare the budget, sponsor and exercise primary support responsibility for Naval Air Engineering Center.

In addition, a draft NAVAIRINST 13800.1C, in establishing the aviation and shipboard interface management procedures to be followed within the Naval Air Systems Command headquarters, sets forth assignment of primary responsibility for coordinating aeronautical weapon system compatibility requirements and assuring that ships are modified, or built, to accommodate these requirements. "...AIR-537 is charged with identifying aeronautical weapon system and ship system compatibility interfaces within NAVAIR HQ and with coordinating and resolving such interface matters with the other elements of the naval establishment. Specifically, within the Navy Department it means that AIR-537 coordinates these matters for the Naval Air System Command with the Chief of Naval Operations, Headquarters Marine Corps, Naval Material Command, Naval Sea Systems Command, and the other systems commands, as required. Staff and support for these functional responsibilities are provided by the Ship-Installations and Configuration Control Branch (AIR-5371)."

b. THE AERONAUTICAL INSTALLATIONS AND CONFIGURATION CONTROL BRANCH (AIR-5371). The Aeronautical Installations and Configuration Control Branch

(AIR-5371) is responsible for the shipboard installation of all aeronautical equipment and is responsible for planning and controlling programs which ensure compatibility between aircraft systems and the shipboard environments.

THE AIRCRAFT LAUNCH AND RECOVERY EQUIPMENT BRANCH (AIR-5372). The Aircraft Launch and Recovery Equipment Branch (AIR-5372) is responsible for:

- Providing the functional management of material acquisition and ILS for catapults and arresting gear from inception throughout service life.
- Developing data for NATOPS (Naval Air Training and Operating Procedures Standardization).
- Ensuring that NATOPS publications reflect current aircraft configurations of ship installations equipment.
- Sponsoring and managing applied research, test and evaluation programs at NAEC.

2. NAVAL AIR ENGINEERING CENTER (NAEC). The draft Naval Air Engineering Center (NAEC) organizational manual (NAECINST 5450.2) forwarded to Naval Air Systems Command (AIR-920) 8 September 1978, reflects the organizational relationships presently functioning within the command.

a. TECHNICAL DIRECTOR (NAEC-09). The Technical Director (NAEC-09) is identified as being responsible to the Commanding Officer for the direction and management of the Center's technical programs and for planning coordination, supervision and control of the technical programs carried out by the six technical departments and technical staff. He "...develops and/or changes the policies, plans and procedures of the technical effort of the Center..., has the authority to make final decisions on requests and recommendations submitted by center personnel for the initiation of theoretical and experimental investigations, not previously authorized, and on proposals for major programs or changes to assigned programs to be submitted to higher authority for consideration." He is the principal advisor to the Commanding Officer on all scientific and technical programs under the center's mission.

b. TEST AND EVALUATION COORDINATOR (NAEC-902). The Test and Evaluation Coordinator "...provides overall review and coordination in the planning, evaluation and accomplishment of test and evaluation programs on launching...'and'...recovery systems. Advises the Technical Director NAEC on the relevance of the technical programs underway or planned, and proposes reduction or curtailment of the efforts when imbalances become evident or points of diminishing returns are reached...Monitors overall effort in terms of effectiveness of technical approaches, quality output, and achievement of program objectives. Coordinates plans and schedules for all test programs. Provides leadership to promote a productive engineering test climate."

c. TECHNICAL DEPARTMENTS

(1) SHIP INSTALLATIONS ENGINEERING DEPARTMENT (NAEC-91). The Ship Installations Engineering Department (NAEC-91) manages and conducts research, development, systems integration, fleet engineering and logistics support and conducts certification programs. The department has two primary divisions; the Aircraft, Weapons, Ships and VLA Division (NAEC-911) and the Launching and Recovery Division (NAEC-912). The Launching and Recovery Division has the prime responsibility concerning the catapult and arresting gear and "Conceives, plans, designs, and conducts research and development programs on existing and proposed equipments and systems...provides in-service engineering logistics support for the fleet...".

(2) GROUND SUPPORT EQUIPMENT DEPARTMENT (NAEC-92). The Ground Support Equipment Department (NAEC-92) is responsible for all GSE technical programs.

(3) ENGINEERING SPECIFICATIONS AND STANDARDS DEPARTMENT (NAEC-93). The Engineering Specifications and Standards Department (NAEC-93) develops standardization documents and conducts other related projects associated with aircraft and missiles.

(4) TEST DEPARTMENT (NAEC-94). The Test Department (NAEC-94) "...conducts development tests and evaluations for all equipment and systems developed by NAEC; conducts certification tests of shipboard installed launching equipment; operates test sites for development tests and evaluations on equipment for contractors, other government agencies and allied foreign countries. Conducts research and development of equipment and instrumentation used in development tests and evaluation. Although there are other divisions within the test department, the two immediately related to catapult and arresting gear are the Launching Division (NAEC-941) and the Recovery Division (NAEC-942). Respective of their hardware interests, both have like responsibilities relative to test and evaluation, and independent research and exploratory development, and analysis of test data and preparation of reports to include recommendations on suitability of equipment for service use."

(5) FLEET TECHNICAL SERVICES DEPARTMENT (NAEC-95). The Fleet Technical Services Department (NAEC-95) provides technical services to the aircraft carriers in support of installation, operation, overhaul, maintenance repair, inspection and certification, technically assists in monitoring and coordinating the NAVAIR effort, and provides (3M) maintenance and material management functions for fleet and shore activities. There are two primary divisions relating directly to the catapult and arresting gear.

(a) MAINTENANCE AND MATERIAL MANAGEMENT (3M) DIVISION (NAEC-951). The Maintenance and Material Management (3M) Division (NAEC-951) is responsible for Planned Maintenance Systems (PMS), Maintenance Data Collection Systems (MDCS) and the development of preventive maintenance, phase maintenance, and quality assurance maintenance requirements. This division reviews training courses, manuals and other publications utilized in training, operations and maintenance for technical accuracy and operational practicability.

(b) FLEET RESPONSE DIVISION (NAEC-952). The Fleet Response Division (NAEC-952) provides technical services to all field activities in support of installation, operation, overhaul, maintenance, repair, inspection and certification, and provides continuity and technical liaison between NAEC operating departments in response to fleet needs. Services are provided directly by division representatives located at NAEC Field Service Branch offices (formerly CAFSU) at seventeen locations in the field.

(6) DEVELOPMENT AND SITE SUPPORT DEPARTMENT (NAEC-96). The Development and Site Support Department (NAEC-96) provides development and site support for the field installation at NAS Lakehurst.

3. ORGANIZATIONAL HISTORY. The organizational relationship and responsibilities as previously discussed are the final result of previous Shore Establishment Realignment (SER) action, NAEC, NATF, and NAF Lakehurst consolidation, and the transfer of some technical responsibilities from NAVAIR to NAEC. Prior to 1955, the functions of NATF and NAEC existed under the same command located at Philadelphia. In 1957 NATF was established as a tenant command at NAS Lakehurst. In 1973, in response to a centralization requirement (SER), NAEC commenced planning and execution of a move from Philadelphia. By 1975 NAEC was fully established at NAS Lakehurst. In March 1977, the former NAEC, NATF and NAF Lakehurst were combined into a single command with the title of Naval Air Engineering Center (NAEC). In the phase one organization, the functions of the three previous commands were absorbed by three groups (Support, Engineering and Test) within NAEC. Subsequently, those groups were reformed into the present technical departments and a command support organization of eight departments. No reductions in force (RIFS), nor grade reductions, occurred with the SER and the consolidation. Imposed ceiling reductions of approximately 50% over the period from 1972 to 1979 have been achieved through attrition. Some high grade billets were lost and some new job titles became less prestigious.

a. TRANSITION AGREEMENT. A Naval Air Systems Command/Naval Air Engineering Center Philadelphia letter of agreement set forth the transition of engineering cognizance of selected items from NAVAIR (537) to NAEC. This transition was to commence in 1973 and included maintenance engineering and design functions and delegation of authority. Specific delegation of authority includes: "Decisions made in engineering matters pertaining to assigned service equipment will not normally require approval by NAVAIR; however, since funding responsibility, overall effectiveness and safety-of-operation of the equipment in question remain the responsibility of NAVAIR, the following procedural constraints and restrictions on the exercise of authority shall apply: 'actions which would preclude operational use or otherwise reduce or limit the operational effectiveness of the equipment are reserved to NAVAIR (AIR-537)'...significant design change and service equipment change approval must be accomplished by and within NAVAIR. (NOTE: A significant equipment change is defined as one which exceeds the CFA's FY funding authority for accomplishment)...Investigations requiring extensive engineering effort...shall not be undertaken without prior NAVAIR approval."

III

DECISION MAKING PROCESS

A review of the problem solving process by tracing the steps surrounding the aforementioned selected problem areas provides insights concerning the overall decision making process.

1. Summary of Problem Areas Reviewed. Each of the problem areas were traced through the decision chain in-depth. For the sake of simplicity, only a summary of each problem area is provided.

a. Capacity Selector Valve (CSV) Summary. The capacity selector valve was developed as a method for controlling constant steam pressure catapults. The CSV varies the launch valve opening rate while maintaining constant steam pressure. (Prior to the constant pressure system, catapult performance was controlled by adjusting the steam pressure while the launch valve opened at a fixed rate.) The capacity selector valve ultimately responds to a three digit command setting selected by dialing appropriate selector knobs at the center deck command station (CV 41 and CV 67) or the Integrated Catapult Control Station (ICCS) (CVN). The commanded setting is coded and transmitted to the electronic assembly and the motor that turns the shaft positions the capacity selector valve. An electromechanical feedback system provides a match of the commanded setting and the console indicators when the capacity selector valve is properly positioned.

After more than 200,000 successful launches by the constant pressure catapult the first serious malfunction of the command and indicating system of the CSV occurred aboard USS MIDWAY in March 1977, resulting in the loss of an A-7 aircraft. In this case electrical continuity was achieved which bypassed the safety interlock system and allowed the firing of the catapult with superimposed numbers on the indicators. The actual valve setting (098) was one-hundred units below the selected setting (198). The 1 and 0 in the hundreds column were superimposed at the console operators station which, procedurally, calls for suspension of the launch until the ambiguity is resolved.

To resolve the ambiguity, NAEC installed a redundant readout at the console operators station on CVs 41 and 67 within two weeks. Additionally, NAEC subjected the electronic control and indicator system to a Failure Mode and Effects Analysis (FMEA). As a result of the FMEA, 6 major and 36 minor single point failures were identified that could result in a malfunction of the system. The redundant readout at the console operators station was selected as the short term solution and a newly designed electronic system was selected as the long term solution.

A second A-7 was lost in June 1978 during launch operations aboard the USS KENNEDY. In this case, with the CSV indicator malfunctioning, the redundant readout indicating 100 units below the desired setting, and the CSV malfunction light illuminated, the console operator selected the "defeat interlock mode" and fired the catapult.

When the initial accident occurred the decision was made to install the redundant readout in CVs 41 and 67 since those systems were found to be most critical in the FMEA. However, following tests in February 1979, a redesigned redundant readout kit will be ready for service change installation in the 20 CSV system catapults presently in the Fleet.

The most serious CSV problems were due to the existence of 42 potential single point failures in the electronic system as identified by the FMEA. The long term solution to the problem began in 1977 with the conceptual design of a new electronic package to eliminate the potential failure points.

In September 1969, the potential for the indicator ambiguity (superimposed numbers) in the hundreds column was first mentioned in an internal NAEC report. Also, in April 1970, NATF recommended that each number be independently generated to avoid superimposition. NAEC forwarded the recommendation to the contractor as having merit and requested investigation. However, because of the contractor emphasis that only the tens column could be superimposed, and due to the strong reliance on the safety interlock system in preventing a launch with an improper CSV setting, no service change action was taken.

In April 1978, a contract was signed which required the design of the advanced electronic control assembly, the manufacture of two prototype assemblies, the software provisions, and the accomplishment of environmental tests. The first prototype has been installed at NAEC's test site at Lakehurst and tests have commenced. The sub-contracted environmental tests on the second system are underway and are being monitored by the NAEC QA office. The improved control assembly should be ready for ship installation in approximately October 1980.

b. NOSE GEAR LAUNCH SPREADER SUMMARY. The loss of an F-14 aboard USS RANGER in September 1978 was the first indication that an improper nose gear launch bar hook-up could result in premature shedding of the launch bar during the catapult stroke. (Fortunately, a portable TV camera unmistakably recorded the improper hook-up.) Prior to the F-14 loss, some 42,000 successful launches had taken place and it was postulated that a premature shedding of the launch bar on the catapult stroke could not occur. The launch bar/spreader interface was specifically designed to cause the bar to properly seat, or to cam up and over the spreader during tensioning if nose gear misalignment was too great. Existing directives require the hook-up petty officer to visually inspect all aircraft launch bar/spreaders for proper hook-up. In the case of the RANGER accident, the hook-up petty officer failed to properly inspect the bar/spreader hook-up and did not notice the improperly seated launch bar.

NAEC, upon notification of the accident, immediately took action to obtain the nose gear launch spreader and TV camera tapes in order to commence post-accident analysis without delay. Indentations on the nose of the spreader in conjunction with TV camera tape analysis clearly established that the nose gear launch bar hung up on the nose of the spreader. After a series of NAEC tests (though unable to duplicate the RANGER circumstance), it was determined that the solution to the problem rested in preventing the bar from camming up and over the spreader. It was also determined that misalignment of the bar as the aircraft taxies into position is the major contributor to the camming problem. The design of the spreader side plates and chamfer (beveled) areas also contribute to the misposition problem. Following redesign evaluation and testing, an interim service change was issued on 6 December 1978 which provides modifications to the spreader in the areas of changing the chamfer and the side plates, and requires the installation of nose wheel guides on the deck of the carrier. The changes were incorporated on CV 63 catapult number one in late December. Tests with an F-14 were conducted 10 January with satisfactory results.

Reports of the 1972 aircraft compatibility tests conducted by NATF indicated that no launch bar/spreader interference/binding problems were encountered during taxi-in or hook-up. Later (January 1974) in an NATF letter after observing shipboard operations, it was reported that the F-14 launch bar could be kicked over the catapult spreader during the tension stroke. In October 1975 following aircraft/ship compatability trials on USS NIMITZ (CVN 68) an NATF letter reported that the F-14 launch bar could be cammed up by the spreader during the pre-tension phase of catapult launch operations and, in one of twenty seven other items, recommended the performance of a design study to provide additional chamfer to the nose gear launch spreader. The NATC final report on the NIMITZ certification tests did not report the launch bar/spreader as a problem area since any misposition of the bar relative to the spreader was determined as always "fail-safe" with no possibility of the bar hanging on the nose of the spreader after tension. Additionally, it was clearly documented that an inspection of the nose gear bar/spreader interface was required prior to launch.

Statistical data of the camming up and over problem from fleet experience does not exist; however, it is a common practice for the hook-up petty officer to utilize his foot in an attempt to aid seating the bar during pre-tension. The camming up and over has been treated as merely a "nuisance" problem which occasionally causes launch delay.

c. CROSS DECK PENDANT (CDP)/CAT SLOT INTERACTION PROBLEM SUMMARY. The CDP/CAT slot problem surfaced in March 1978 when an F-14 was lost due to failure of the No. 4 crossdeck pendant during recovery operations on the USS KENNEDY (CV 67). The post accident metallurgical investigation of the failed crossdeck pendant revealed that the wires were heavily abraded and had suffered significant heat damage in the failed area. Wear marks could be seen across the wires approximately normal to the strand axis. It was determined that the wires were being progressively damaged and weakened by being dragged through the No. 3 catapult slot during the retraction cycle. Shipboard tests supported this conclusion when the CDP was purposely placed in the CAT slot; after only two retractions, heavy abrasion similar to the failed CDP was noted.

Interim operating and inspection procedures were immediatly published which, among other things, called for removal of the CDP from the slot prior to retraction and detailed inspection in the event the CDP should fall into the slot during retraction.

NAEC asked for a survey from all carriers in order to determine the scope of the problem. The results showed the frequency of occurrance to be approximately 4% on most ships with the worst case of 10% on CVs 66 and 67. Based on subsequent surveys, the frequency was found to be nearly double that of the early survey. Additional tests conducted aboard CV 64 and CVN 69 determined that any measure other than covering the catapult slot was ineffective.

The final design consists of a number of two-bolt "buttons" that are inserted in the catapult slot at optimum spacing. The "button" design was successfully tested on CVs 63 and 67 and those buttons were retained by the ships for their use. An Interim Catapult Service Bulletin was issued for CV 67 and a similar bulletin for long term use on other carriers is being prepared. An Arresting Gear Service Bulletin changing the wire rope inspection and replacement criteria has been issued.

In NAEC's development of a solution to the problem, many other concepts were considered and rejected for valid reasons. One fix that remains feasible is the utilization of an inflatable (air bag) slot seal which has been manufactured and is enroute to NAEC for tests. Following the tests, NAEC plans to hold the installation in abeyance if the "buttons" continue to perform satisfactorily.

Why, with all the previous years of operations, the crossdeck pendant/CAT slot interaction problem had not surfaced prior to March 1978 could not be determined.

d. ARRESTING GEAR FLOW CONTROL VALVE FLANGE PROBLEM SUMMARY. In November 1977, an F-14 was lost during recovery aboard USS AMERICA (CV 66) when the CDP parted following "two-block" of the arresting gear engine. The cause of the accident was the failure of the flow control valve retaining studs due to improper maintenance and lack of quality assurance procedures.

The flange of the flow control valve assembly is mated to the piping flange by several stud/nut retainers. Due to leakage around the flange (subjected to 10,000 PSI hydraulic pressure during the final stage of arrestment), corrective maintenance had been performed three times during the three weeks preceding the mishap. During flange mating improper stud centering prevented proper stud-to-nut engagement. These circumstances were not reported to supervisory personnel, nor did any supervisor inspect the flange during or after the maintenance actions.

Several recommendations were made during the course of investigation of the problem which included:

(1) Investigate the feasibility of installation of an improved stud/bolt system.

(2) Development of a "critical system" listing for catapults and arresting gear.

(3) Investigate the possibility of monitoring equipment, parts and assembly usage/failure data for trend analysis purposes.

(4) Monitor training publications and maintenance manuals for completeness and to ensure that revisions are incorporated.

(5) Investigate existing inspection criteria to ensure established standards are being met.

(6) Monitor ABE "A" school instruction to ensure that "lessons learned" are incorporated in the syllabus and completely understood.

NAEC's response to solve the flange integrity problem was to issue a service change incorporating replacement of all studs with a fixed head bolt, manufactured at NAEC, which eliminates the studs completely. NAEC has embarked upon compiling a "critical system" listing and instituted changes to MRCs which reflect a QA inspection/witness at critical points in maintenance procedures. In addition, NAEC has made a concentrated effort to update and validate all publications. The interface between the monitoring of the training and the functions of ABE "A" school regarding timely incorporation of "lessons learned" is presently being conducted on an informal basis between NAEC and NATTC Lakehurst. The circumstance surrounding the flow control valve flange problem was known to the NATTC instructors. Since aircraft accident reports are not received by NATTC, the ABE "A" school relies heavily upon the informal feedback from NAEC.

IV

MAINTENANCE

1. PREVENTIVE AND CORRECTIVE MAINTENANCE. NAEC establishes standardized procedures to conduct catapult and arresting gear preventive maintenance and publishes the manuals required to accomplish corrective maintenance. Maintenance publications and PMS maintenance requirement cards (MRC) are adequate, though some publications are in need of update. Steps have been taken to initiate a fleetwide phased maintenance program for catapult and arresting gear.

A review of maintenance publications, PMS requirements, and discussions with NAEC personnel reveals the absence of a formal Quality Assurance (QA) program (an informal program has been functioning for years with the work center supervisor and maintenance officer exercising conscientious supervision and inspections). NAEC has recently initiated the insertion of Quality Assurance Inspection/Witness requirements on some MRC's; however, because the catapult and arresting gear equipment directly involves life and death safety considerations, a comprehensive Quality Assurance program is essential.

2. DISCREPANCY REPORTING (FEEDBACK). NAEC problem investigation is initiated by various forms of feedback from fleet units as well as internal test, engineering and quality assurance actions. NAEC, as a designated Cognizant Field Activity (CFA), receives notification of discrepancies by various means which includes the following:

- Casualty Reports (CASREPT) submitted in accordance with NWP-7.
- Aircraft Incident/Accident report messages submitted in accordance with OPNAVINST 3750.6 series.
- Engineering Investigation requests submitted in accordance with OPNAVINST 4790.2A.
- Deviation from Normal Arrested Landing or Catapult launch report in accordance with COMNAVAIRPACINST 13800.6B and COMNAVAIRLANTINST 3750.30J.
- PMS/MRC feedback reports submitted in accordance with OPNAVINST 4790.4.
- Fast Action Discrepancy Report (FADR) submitted in accordance with requirements contained in each NAVAIR operations and maintenance manual.
- Field Technical Service Field (CAFSU) reports submitted internal to NAEC.
- Test, Engineering and Quality Assurance reports internal to NAEC.

APPENDIX III

- Other reports from NAVAIR and TYCOMS of an informal nature which includes messages, letters, phone calls and meetings.

A voluminous amount of data and information is shared among the cognizant personnel within the NAVAIR/NAEC/TYCOM organizations. All forms of communications are utilized in the pursuit of solutions to problems as they are discovered; however, no discernable system is established which provides for trend analysis on parts or component failures if the failure does not lead to accident, injury or equipment damage.

V

TRAINING

1. ORGANIZATIONAL RELATIONSHIP. NAVAIR 537, as specified in NAVAIRINST 5400.1A, is assigned the responsibility for training for shipboard launch and recovery equipment and NAVAIR-5372 is responsible for the development of data for NATOPS. NAEC and the Naval Air Technical Training Command (NATTC), ABE 'A' School, are co-located at NAS Lakehurst and the ABE training curriculum development is accomplished on site in conjunction with NAEC and fleet inputs.

2. ABE TRAINING. A few years ago ABE 'A' school was a 16-week course of instruction that provided both classroom and hands-on training. Revised instructional techniques and the pressure of reduced funding/manning has reduced this course to the present 6.6 wks. The reduction has led to a basic theoretical course of instruction with minimal hands-on training, the thought being that students would receive the background in 'A' school and the remainder of training through on-the-job-training (OJT) on their assigned ship.

The personnel accession and retention problems in recent years has lessened the available numbers of quality student inputs. The basic GCT/ARI combination required for ABE school was reduced from 112 to 96. Certain automatic and near automatic waivers lower this average figure even further. Some reenlistment promises have occasionally resulted in extremely low GCT/ARI combinations being inducted into the school. Senior Petty Officer rate conversions have also had detrimental effects on the rate. This occurs when a senior petty officer converts and proves to be of questionable suitability when on the job. He is charged against the ship as an E5 or E6 and is not capable of accomplishing the assigned tasks.

ABE school officials at Lakehurst indicate that the quality of personnel currently being inducted has forced a change in the instructional techniques. Basic deficiencies in reading skills has caused extensive repetitive after-hours training of students. A new, slightly longer curriculum for the ABE 'A' school has recently been approved that will shift the emphasis to more hands-on training on the equipment.

The ABE 'A' school personnel are responsive to inputs received, such as accident reports, etc., and to NAEC cross talk; however, in spite of the co-location, the NATTC hands-on catapult trainer has not been updated to incorporate recent fleet service changes and modification such as the CSV and its indicating system.

(U)

CONCLUSIONS

1. The review of the adequacy of management of design, development, test and evaluation, production, installation and certification of catapults and arresting gear produced the following conclusions:

a. That the overall management is efficient and effectively executed.

b. That the existing organization and organizational relationships are cost effective and contribute to close communications within cognizant technical shore, and fleet, communities.

c. That the necessary checks and balances within NAEC engineering and test organizations are adequate to ensure a thorough airing of problem areas.

d. That NAVAIR 537 carries out the assigned responsibilities on a "management by exception basis" and is viewed by NAEC as "the" decision maker for significant controversial points.

e. That the preventive and corrective maintenance procedures do not include a comprehensive quality assurance program.

f. That the corrective maintenance system does not contain reporting that provides trend analysis on all failed/malfunctioned parts or components.

g. That Failure Mode and Effects Analysis (FMEA) procedures are not applied to all major components, but only to selected items of significant concern.

h. That significant equipment operating procedures are not in CV NATOPS. Deviations from normal operating procedures affecting safety do not require approval from appropriate authority.

i. That the Navy's current problems in recruiting and retention are having a negative impact on the training qualification and certification of catapult and arresting gear personnel.

APPENDIX III

VII

RECOMMENDATIONS

1. Based upon analysis of the information gathered during the course of this management review, the following recommendations are submitted:

   a. Submit to the CV NATOPS "Model Manager" an expansion, as necessary, of sections IV, V and VI of the CV NATOPS to include those deviations from normal operating procedures which require approval by Commanding Officers or other appropriate authority.

   b. Take the necessary steps to institute quality assurance (QA) requirements within the Preventive and Corrective Maintenance programs.

   c. Institute an expanded reporting requirement for compilation and analysis of all failed or malfunctioning parts or components.

   d. Execute the Failure Mode and Effects Analysis (FMEA) procedures on all major components.

   e. Conduct an indepth review of training, qualification and certification requirements and take actions or make appropriate recommendations as required.

   f. Accelerate the update modifications of the training equipment at NATTC ABE "A" School.

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