DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE SAFETY CENTER

AFSC/CV
9700 G Avenue SE, Suite 240
Kirtland AFB NM 87117-5670

16 APR 2002

Mr. John Greenewald, Jr.
[redacted]

Dear Mr. Greenewald

In reply to your 23 October 2001 Freedom of Information Act request which was received by 88 CG/SCCMF, Wright-Patterson AFB OH and forwarded to the Air Force Safety Center on 19 March 2002, attached is AD Number B128378, entitled *Reporting Nuclear Safety Deficiencies (Dull Swords on the F-16 Aircraft,* dated September 1988.

Portions of the report have been redacted. They are not releasable for the following reason: The information is either proprietary or restricted from release by the Arms Export Control Act and the United States Code, Title 5, Section 552(b)(4), and DoDR 5400.7/Air Force Supplement C3.2.1.4.

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> Secretary of the Air Force
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I hope this information is helpful.

Sincerely

JEFFREY G. BLANCHETTE, Colonel, USAF
Vice Commander

Attachment:
AD Number B128378

Reporting Nuclear Safety Deficiencies (Dull Swords) on the F-16 Aircraft.

AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH

SEP 1988

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Wright-Patterson Air Force Base, Ohio

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AFIT/GLM/LSM/88S-29

REPORTING NUCLEAR SAFETY DEFICIENCIES

(DULL SWORDS) ON THE F-16 AIRCRAFT

THESIS

William J. Hammer
Captain, USAF

AFIT/GLM/LSM/88S-29

Distribution ~~limited~~ auth to U.S. Government Agencies and their Contractors; Administrative/Operational Use. 12 September 1988. Other requests for this record must be referred to Det 1, AFISC/SNA, Directorate of Nuclear Surety, Kirtland AFB NM. 87117

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AFIT/GLM/LSM/88S-29

REPORTING NUCLEAR SAFETY DEFICIENCIES (DULL SWORDS) ON THE F-16 AIRCRAFT

THESIS

Presented to the Faculty of the School of Systems
and Logistics of the Air Force Institute of Technology
Air University
In Partial Fulfillment of the
Requirements for the Degree of
Master of Science in Logistics Management

William J. Hammer, B. S.
Captain, USAF

September 1988

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Abstract

The purpose of this research was to determine what problems existed for reporting Dull Swords on the F-16 and what improvements could be made to the cumbersome investigation and reporting process. The complexity of the F-16's multiplexed arming, monitoring and control system (MUX AMAC) was determined to be the major problem source. Personnel involved in the reporting process were uncertain of what failures to report as Dull Swords, because most of the MUX AMAC circuitry and components were used to deliver conventional weapons (i.e. missiles and bombs) and nuclear weapons. Safety personnel interviewed desired more detailed reporting guidance on this dilemma.

MUX AMAC experts were interviewed to determine what types of failures needed to be reported and what type of information is needed in the reports. This information was used to develop better reporting guidance for units to follow.

The guidance developed was then used in conjunction with two computer products: a maintenance history report on each of the major MUX AMAC components obtained from the Central Data System (CDS) and a Dull Sword summary report obtained from the Directorate of Nuclear Surety's AID Data.

File to determine whether units had been reporting a representative number of Dull Swords. The analysis found

that over 5Ø percent of the Nuclear Remote Interface Units failures were not reported, as well as several Dull Swords on other components. The author suggested that many other Dull Swords may have occurred, but this could not be confirmed due to superficial information being entered into the CDS.

The author analyzed the possibility of using the CDS or similar systems to replace or improve the current reporting system. The research found that the investigation/reporting process at units could be streamlined if more detailed information was entered into the systems. Several recommendations for improvement were given.

REPORTIN NUCLEAR SAFETY DEFICIENCIES (DULL SWORDS) ON THE F-16 AIRCRAFT

I. Introduction

The Air Force Nuclear Surety Program

The Air Force Nuclear Weapons Surety Program was developed to ensure that all requirements of the Department of Defense (DOD) Nuclear Weapon System Safety Standards are met (11:2). These DOD standards provide guidelines to design, maintain, transport, store and use nuclear weapons and/or nuclear weapon systems to guarantee their safety and security (10:2). The DOD standards state:

> a. There shall be positive measures to prevent nuclear weapons involved in accidents, or jettisoned weapons, from producing a nuclear yield.
> b. There shall be positive measures to prevent DELIBERATE prearming, arming, launching, firing, or releasing of nuclear weapons, except upon execution of emergency war orders or when directed by competent authority.
> c. There shall be positive measures to prevent INADVERTENT prearming, arming, launching, firing, or releasing of nuclear weapons in all normal and credible abnormal environments.
> d. There shall be positive measures to ensure adequate security of nuclear weapons, pursuant to DOD Directive 5210.41 (10:2).

Meeting the four DOD standards was not a simple task and required the United States Air Force (USAF) to provide guidance to all of its echelons. To help understand this guidance and other aspects of this thesis, key terms are defined in the appendix. Air Force Regulation 122-1, the Air Force Nuclear Weapons Surety Program, gives the basic guidance for complying with the standards and assigned responsibilities to Air Force commands, agencies, and units. To implement the program, numerous regulations and sub-programs were instituted. For example, the USAF Two-Man Concept (AFR 122-4) was instituted to help ensure that lone individuals do not have access to areas that contain nuclear weapons or nuclear weapon systems. This concept eliminated the possibility of a person tampering with the weapon or weapon system without the knowledge of another person, since persons allowed in these areas known as "No Lone Zones" must be paired into teams of at least two people. The USAF Personnel Reliability Program (AFR 35-99) was instituted to ensure that only the most reliable person are given access to nuclear weapons or nuclear weapon systems. Under this program, personnel are thoroughly screened prior to being given duties involving nuclear weapons and continuously monitored thereafter. When a problem arose that may have affected an individual's reliability, the person's commander determined whether or not that person could continue with his/her assigned duties. The USAF Nuclear Weapons Security Program (AFR 207-10) was instituted to ensure that nuclear weapons and nuclear weapon systems were continuously guarded from hostile forces. The program requires complex security systems around these vital resources backed by sufficient military forces at all times (12:2).

Reporting Requirements. The Investigating and Reporting USAF Mishaps Regulation (AFR 127-4) also contains information related to the AF Nuclear Surety Program. The Guidance provided in Chapter 10 was a direct result of the AF Nuclear Weapons Surety Program. It provides the procedures for the investigating and reporting of AF Nuclear Accidents, Incidents and Deficiencies (AID). Nuclear AID reports are required for those mishaps, events or conditions which degrade or could degrade nuclear or radiological safety" (10:80). The reports are transmitted to all levels of command and to other un. , with similar weapons systems to provide valuable information so that preventive actions could be taken to prevent similar mishaps or to evaluate and/or correct safety deficiencies.

Nuclear AID reports are broken down into four distinct categories: Nucflash, Broken Arrow, Bent Spear and Dull Swords, with Dull Swords being the least significant and most common (10:80-81). The first three categories are often referred to as the "accident and significant incident" portion of AID reporting. Dull Swords are often referred to as the "less significant incident and deficiency" portion of AID reporting. This research focuses on the Dull Sword reporting process.

General Issue

The proper investigation and reporting of Dull Swords has often resulted in better designed equipment or systems and improved technical data and directives. However, as weapon systems and equipment became more complex, the investigation and reporting of Dull Swords became more difficult (23; 25; 26; 31; 33). Older weapon systems such as the B-52, F-4 and F-111 aircraft were designed so that their Aircraft Monitoring and Control (AMAC) systems for nuclear weapons were electronically isolated from their conventional/non-nuclear systems. This was accomplished by using separate electrical hardwired circuits and components for each system. This made it relatively simple to determine whether a deficiency meeting the criteria for a Dull Sword existed since the circuits did not overlap. With the advent of multiplexed electronic circuitry in newer computer-driven weapons systems such as the F-16, the determination of whether a Dull Sword existed became increasingly difficult (5; 23; 25; 26; 31; 33; 34). The electrical circuits for the conventional and nuclear weapons release systems were no longer totally separate systems. Now the same circuits and components or portions of them were used to monitor and release both conventional and nuclear weapons. The determination process is further complicated by the use of computer hardware and software in the F-16's "multiplexed AMAC" (MUX AMAC) (33).

For example, a : ores management system (SMS) component of a F-16 used to release a conventional bomb or to fire an air-to-air missile and may also be needed to release a nuclear weapon. Herein lies the reporting dilemma. If the component failed during an air-to-air training mission, should a Dull Sword be reported on that component even though a nuclear mission was not being simulated? This question cannot always be easily answered since the particular malfunction or circuit within the component that failed, may or may not have affected a nuclear mission (3; 5; 23; 25; 26; 29; 30: 33). Depending on the complexity of the failure, an intricate knowledge of the SMS and its circuitry plus the numerous computer hardware/software combinations may be needed to determine if a Dull Sword occurred (33). In practice, it is sometimes difficult to get SMS systems enginee.'s to agree on what constitut.s a Dull Sword (5; 23; 6; 29; 30; 33).

The complexities involving the reporting of Dull Swords on multiplexed weapon systems exemplified the management questions which forms the basis of this thesis, "What can be done to improve investigating and reporting of Dull Swords on F-16s?"

Specific Problems

Air Force Regulation 127-4 requires that Dull Swords be reported on "damaged, malfunction or failure of nuc ear capable combat delivery vehicles, suspension, rele se, launch, separation, arming, monitoring and control systems" (10:81). This broad definition was easily applied to older AMAC systems; but there has been considerable controversy surrounding how to interpret the definition when applying it to the F-16's MUX AMAC. The following section provides examples of the reporting dilemma.

Personnel at some F-16 units may interpret the definition to mean that Dull Swords should be reported at the Line Replacement Unit (LRU) level every time an LRU of the SMS failed, excluding the Nuclear Remote Interface Unit (NRIU) (21, 24, 25, 28, 33). However, this interpretation would lead to Dull Swords being submitted on situations where the particular LRU failure may not have affected the Nuclear Mode. Following this interpretation could also cause the Dull Sword System to become overburdened with unnecessary reports. This could result in over a thousand reports (4; 21; 22; 26; 28; 33). Additionally, with approximately 50 Dull Swords being reported each year on the F-16 C/D this would increase the current workload by over twenty times. Personnel at other units may interpret the definition to limit reporting of Dull Swords on the F-16 MUX AMAC to deficiencies or failures that occurred when the nuclear mode was tested or when it was used during a training mission (4; 6; 18; 21; 22; 28; 33). This definition would reduce the number of Dull Swords reported on LRUs; however, deficiencies that could affect the nuclear mode would not be reported when they occurred during other modes, which could also defeat the purpose of reporting Dull Swords (4; 6; 21; 23; 28; 33). Finally, personnel may interpret the regulation and report Dull Swords on any deficiencies that could affect the nuclear mode. Using this interpretation would require every MUX AMAC failure to be analyzed to determine if the nuclear mode could have been affected (23; 25; 29; 30; 33). This would seem to be the most logical and beneficial interpretation; however, it highlights a previously noted problem--that it is difficult to assess whether a specific failure would affect the nuclear mode (23; 25; 29; 33).

The particular interpretation of what to report as a Dull Sword may vary among F-16 units. The interpretation followed is influenced mostly by the level of experience/expertise of the unit's nuclear surety personnel (4; 6; 21; 22; 28). Nuclear Surety Officers (NSO) lack specific guidance on Dull Sword reporting and as a result must base reporting decisions on the level of understanding of the F-16 SMS. Some NSOs' understanding is limited to those situations where the decision to report a Dull Sword is obvious, such as a Nuclear Remote Interface Unit (NRIU) failure or the failure of an alert aircraft (4, 6, 21, 22, 28).

An additional problem faced at F-16 units is that NSO is not directly involved in maintenance actions and must rely on maintenance personnel to notify him/her on possible Dull Swords. NSOs must therefore be knowledgeable enough on

F-16 Dull Sword reporting to be able to convey reporting requirements with a high degree of credibility (4; 6; 21; 22; 24; 28). At the same time, maintenance personnel may not know what situations call for a Dull Sword report and will not report the situations to the NSO, which results in no report being submitted and valuable information being lost to the Dull Sword action agencies.

The controversy of how to interpret the regulation has not been resolved. When interpretation is used, it is subject to the beliefs and discretion of those making the decision, thus a standardized Dull Sword reporting system for the F-16 may not exist. This dilemma raised the first specific research problem for this thesis... to develop more specific guidance for reporting Dull Swords on the F-16.

Once a more specific definition or better guidance concerning what constitutes a Dull Sword on the F-16 is developed and implemented, it would be safe to assume that the number of reports may increase (4; 6; 21; 22; 23; 24; 25; 26; 28; 33). This increase could increase the workload for all persons/agencies involved in Dull Swords reporting since more reports would be investigated, reported and analyzed. The increased workload could undermine the intent of the reporting system, especially if units reported only as many reports as they could efficiently manage (4; 6; 21; 22; 24; 25; 28). Thus, due to the cumbersome reporting system, many occurrences may not be reported, and valuable information may not be submitted to the appropriate action agencies for evaluation.

Additionally, even if a more specific definition or better guidance is developed, there is no way of making sure that the NSO and action agencies are notified of all situations requiring Dull Sword reports. Currently, NSOs must totally rely on maintenance personnel to be notified of potential Dull Swords (4; 6; 21; 22; 25). For example, if not notified of an NRIU failure, the NSO will not submit a Dull Sword report to the action agencies.

This situation raises a second research problem for this thesis... to determine if there is an additional source of Dull Sword information which could replace the current Dull Sword reporting or augment it

Research Objectives

1. Develop a more specific definition of Dull Swords for the F-16 and/or provide better reporting guidance.

2. Given the revised reporting requirements found in objective one, determine if a representative number of Dull Swords are being reported by F-16 units.

3. Determine whether there is a better method of reporting Dull Swords or a method available to improve the current reporting system.

Scope and Limitations

This research effort addresses only the F-16, A/D MUX AMAC and reporting Dull Swords on its component failures.

Descriptions of component functions are limited to a non-technical nature so that a technical knowledge of electronics is not needed to understand the research. The research does not refer to any specific F-16 units so that sensitive information on mission taskings is not revealed.

Potential Contributions

It is hoped that this research will contribute to the improvement of the Dull Sword investigation and reporting system. The following are possible contributions:

1) The development of better reporting guidance that can be easily understood.

2) The identification and explanation of problems with investigating and reporting F-16 C/D Dull Swords.

3) The development of suggested improvements of the Dull Sword investigation and reporting system.

II. Literature Review

General

This chapter consists of three sections: F-16 system description and operation, Dull Sword reporting procedures, and computer products. Each section explains a specific area needed to understand this research.

F-16 System Description and Operation

Background. The F-16 is one of the most advanced fighter aircraft in the USAF inventory. "It is a compact, multirole plane designed for air-to-air and air-to-surface attack. It can engage the enemy in aerial combat and then begin air-to-surface attacks using a variety of munitions" (7:1).

> Advanced technologies incorporated into the F-16 make it one of the most maneuverable fighters ever built. The advances include: decreased structural weight through the use of composites; decreased drag resulting in reduced static stability margin; fly-by-wire control; and a high gravitational force tolerance/high visibility cockpit with a 30 degree reclined seat and a single-piece bubble canopy. The F-16 is powered by a single afterburning turbofan engine. All digital avionics are integrated through a digital multiplex system, to reduce permanent wiring as well as to take advantage of the versatility of modern high-speed computers (35:149).

There are currently four versions of the F-16 which are identified as "A", "B", "C", or "D" models. This thesis concentrates on only the F-16C/D models. The F-16C is a single seat model and the F-16/D is a two-seat model. The tandem cockpits in the F-16/D are about the same as the one in the F-16C. The front cockpit can be used by a student pilot with an instructor pilot in the rear cockpit. In addition to being used as a trainer, it can be used for missions requiring two aircrew members (35:150).

The F-16 has nine external stations/pylons from which a wide variety of items can be attached. It can carry a payload of approximately 15,000 pounds consisting of: fuel; conventional bombs and missiles; laser and TV-guided munitions; electronic countermeasure pods; nuclear weapons; and numerous other items. Figure 1 shows these stations and indicates which items can be carried on each. One should recognize that there is almost an infinite number of combinations of items that could be used. For example, an F-16 could be loaded with the following items: AIM-9 air-to-air missiles on stations one, two, eight, and nine; B-6. nuclear weapons on stations three and seven; fuel tanks on stations four and six; and an ECM pod on station five (9:3-130). The F-16 is also armed with an internal 20mm cannon.

Modern technology has made the F-16 easier to maintain than earlier aircraft.

> It has hinged or removable panels for easy access to all components. It has built-in tests and fault and condition indicators. A maintenance fault table stores data to be used to locate problem areas. When a faulty unit is replaced, an automatic self-test shows whether the system is operating. These features reduce the time required to find system failures and replace units. They also reduce the number of flight line maintenance personnel and skill levels required (7:2).

Avionics System Design. The avionics system provides the backbone for the F-16's air-to-air and air-to-ground

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combat capability. [redacted]

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Explaining the function of each of the fire control elements is beyond the scope of this thesis, however three of them will be discussed in detail since they are the key components of the F-16's multiplexed arming, monitoring, and control system (MUX AMAC) for nuclear weapons. These elements include: the MFDS, the EFCC, and the SMS. Since the F-16 was designed to be capable of delivering nuclear weapons, its MUX AMAC was designed to meet all nuclear safety design criteria specified in AFR 122-10 (33).

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The avionics system has a comprehensive fault detection and isolation that supports system maintenance.

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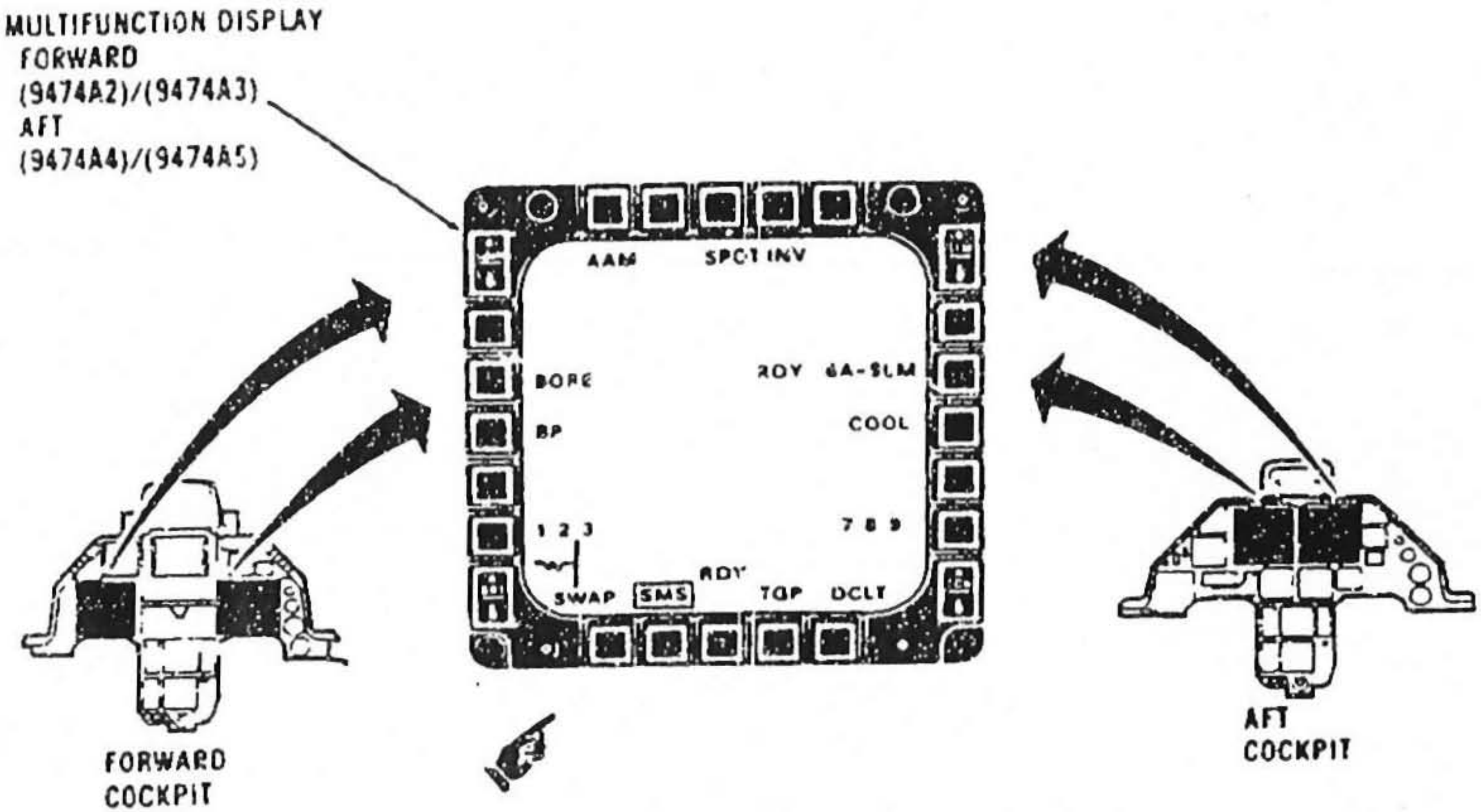

Figure 2. Multifunction Display (8:2-16)

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The SMS consists of several line replacement units (LRUs) and numerous switches and subcomponents that are needed for the F-16's multirole missions. Only the key components of the SMS that are essential for its nuclear role will be discussed in this thesis. The key LRUs are the ACIU, the jettison/release remote interface unit (J/R RIU), and the nuclear remote interface unit (NRIU). The primary subcomponents are: the nuclear consent switch, the master arm and release matrix assembly, and the matrix assemblies for stations three through seven (8:2-1 through 2-18; 18:3-3 through 3-16; 23; 29; 30; 33).

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Dull Sword Reporting Procedures

The main goal of Dull Sword reporting is to bring problems to the attention of agencies that can evaluate and correct them if necessary (10:80). The current method of reporting Dull Swords requires operational units to initiate the reporting process when they discover a potential nuclear safety deficiency. Figure 3 exemplifies the unit's portion of the reporting process.

First, a deficiency is discovered or a failure occurs that may affect nuclear safety. An example of this would be an F-16 failing to drop a BDU-38 (Bomb Dummy Unit used to simulate a nuclear weapon). The wing operations center

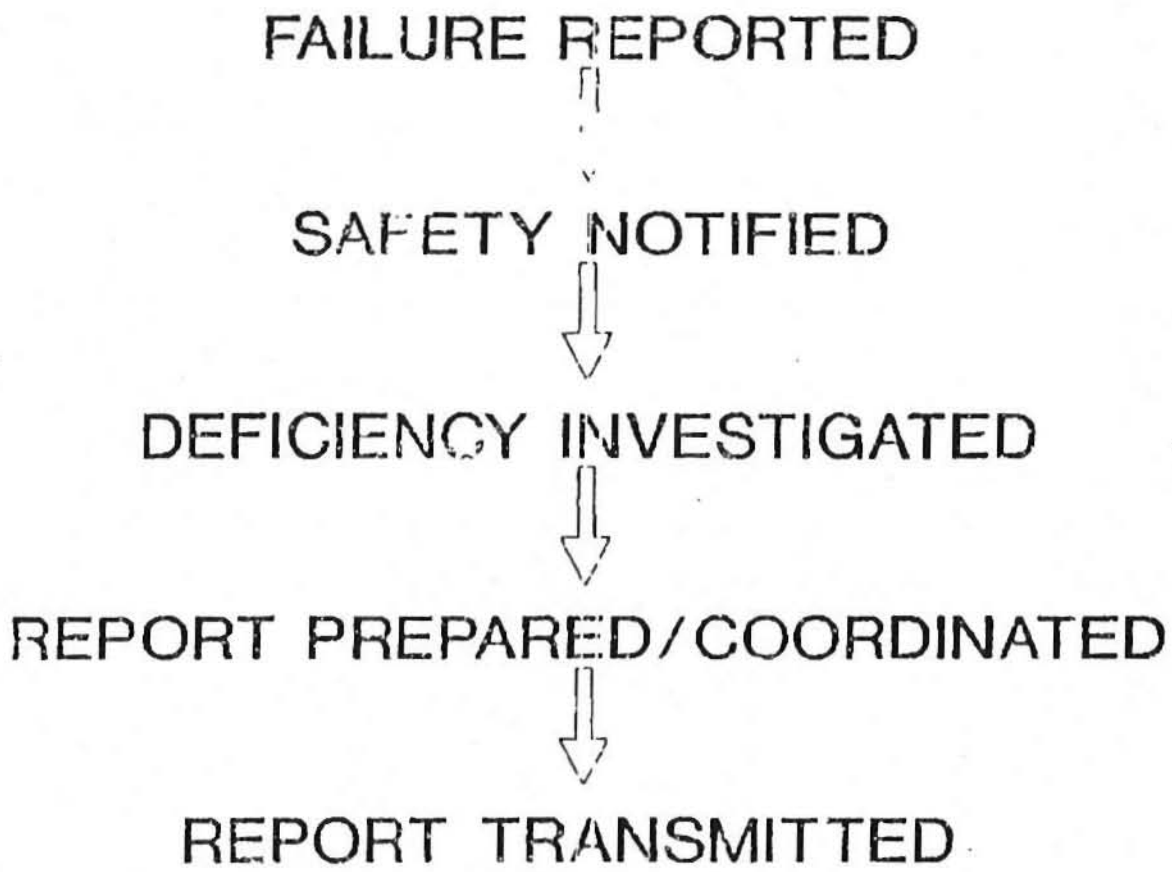

Figure 3. Dull Sword Reporting Process

(command post) or maintenance job control would notify the wing nuclear surety officer (NSO) of the occurrence. The NSO would then investigate the problem by contacting the personnel involved in its discovery and those needed for troubleshooting the failure. Depending on the circumstances, such personnel could include the following: the pilot, pilots of other aircraft that witnessed the event, flightline maintenance personnel involved in troubleshooting the aircraft (weapons loading technicians), non-flightline maintenance personnel involved in troubleshooting aircraft subcomponents (armament shop technicians and avionics intermediate shop (AIS) technicians), contractor technical representatives, and other personnel when deemed necessary. The NSO would concentrate his/her efforts to make sure all necessary information is compiled/reported for the Dull Sword action agencies to evaluate the problem. A typical investigation, such as the one for the given example can take several days to complete.

As the NSO accomplishes the investigation he/she must write the report that is transmitted in message form to the addressees indicated in AFR 127-4, table 10-2. The number of addresses varies depending on the specific item that failed and seriousness of the deficiency. The typical report for F-16 deficiencies (i.e. a defective NRIU) has 13 addressees plus additional ones required by major command supplements to AFR 127-4 (10:88) and prescribes the format and the contents of the Dull Sword report (10:85-86). The report must contain the following information:

1. Date, time and location of the AID.
2. Quantity and type of weapons involved if any.
3. Quantity and type of aircraft involved.
4. Organization, base, and command of the unit reporting the occurrence.
5. Type of operation being performed at the time of discovery or occurrence.
6. Detailed narrative description of all available facts and circumstances pertaining to the Dull Sword.
7. Probable cause of the Dull Sword.
8. Action taken to remedy the malfunction, damage, or error; to provide safety and security; and to prevent recurrence, including repair or replacement actions. Recommended corrective actions, if appropriate.
9. Other reports. If the AID involved another type of report under AFR 127-4, T.O. 00-35D-54, and so forth.
10. Damage or injuries involved, if any. Include status of weapon involved.
11. Explosives ordinance disposal (EOD), medical, or security assistance needed, if any.
12. Whether or not a news release was made. If so, submit a copy of the news release and state to whom it was released.
13. Name, grade, title and phone number of the person submitting this report (10:85-86).

To avoid multiple reports, Dull Swords involving only material deficiencies may be combined with material Deficiency Reports (MDRs) in accordance with T.O. 00-35D-54 (10:83; 15:2-2). The majority of the Dull Swords to be analyzed in this thesis involve material deficiencies and should be reported in combined reports. Maintenance personnel become more directly involved in the investigation and reporting this type of Dull Swords, since they are tasked to prepare MDR reports (15:2-1). The key maintenance personnel involved are known as the "originating point" and the "screening point" (15:2-1, 2-2).

The NSO will work closely with these personnel when investigating and reporting combined MDR/Dull Swords. The combined reports differ in format, but contain the information required by AFR 127-4 and other information required by T.O. 00-35D-54 (10:85-86; 15:2-15 through 2-25). Additional addressees are required by the combined reports (10:83).

AFR 127-4 requires these reports to be transmitted within five duty days of the occurrence, unless the report is combined with an MDR or when the report involves a nuclear weapon (10:90). In the latter two situations, the reporting suspenses are shorter, 72 hours for a combined report and three duty days for a report involving a nuclear weapon (10:90; 15:2-1). If the NSO cannot complete the investigation and transmit the report by the required suspense he/she must submit a preliminary report and subsequent follow-up reports (10:83, 90). When preparing reports to meet these suspenses the NSO must consider the time it will take to complete the following: his/her portion of the investigation; the "originating point's" and the "screening point's" portions of the investigation and report; maintenance personnel's troubleshooting of the aircraft and its subcomponents; preparation of the written report (including typing and proofreading); coordination of the report with local officials; and completion of requested changes.

Many operational units require Dull Sword reports to be coordinated by the senior officials and their staffs prior to transmittal (4; 21; 24; 25). This coordination process can take up to three days to complete due to the availability of the officials needing to coordinate and the method used to distribute the coordination copy of the report (4; 21). Once the report has been coordinated and requested changes are made the message is finally transmitted to required addressees.

The NSO's job is not over with the transmittal of the report. He/she must monitor the status of the deficiency until the report is closed by the appropriate action agency. For combined reports, the NSO must continue to work closely with the maintenance "screening point" to ensure that they both have the correct status of each report (15:2-34). When necessary, follow-up reports and information must be provided to the action agency (10:85-86; 15:2-34). It is not uncommon for an NSO to have several reports open at the same time.

When the action agency/action point (normally the Air Logistics Center responsible for the system or component designated in T.O. 00-25-115) receives the report, they must thoroughly analyze it to ensure that the unit identified the cause of the deficiency and ensure the unit's corrective action was appropriate. They then look at the problem in a broader perspective to see if the problem could recur at the reporting unit or at other similar units. When necessary, guidance will be provided to prevent similar occurrences or the system will be modified.

Figure 4 shows how a combined MDR/Dull Sword is processed through the action point at an Air Logistics Center (ALC). First, the "contact point" will receive the report and assign a Material Improvement Project (MIP) number, if applicable. The contact point will then forward the report to the action point, who will then furnish disposition instructions to the contact point on the deficient item. In turn, the contact point will forward the disposition instructions to the screening point and/or the NSO at the unit that submitted the report. In the meantime, the action point will begin to investigate the deficiency, but may have to wait until the exhibit is received from the submitting unit. If necessary, the action point will request additional help in conducting the investigation from a "warranty manager" or a "support point". Upon completion of the analysis, closing action is forwarded to the contact point who then provides the final response/closing action to the screening point (15:2-34, 3-1 through 3-4).

The time it takes to investigate a Dull Sword and/or conduct a MIP at the action point varies. Some can be accomplished in a matter of days while others may take years to complete (23; 25; 26; 28; 29; 30; 33). An example of the latter case involves the Nuclear Remote Interface Unit (NRIU). System engineers have known for several years that the cause of most NRIU failures has been its exposure to

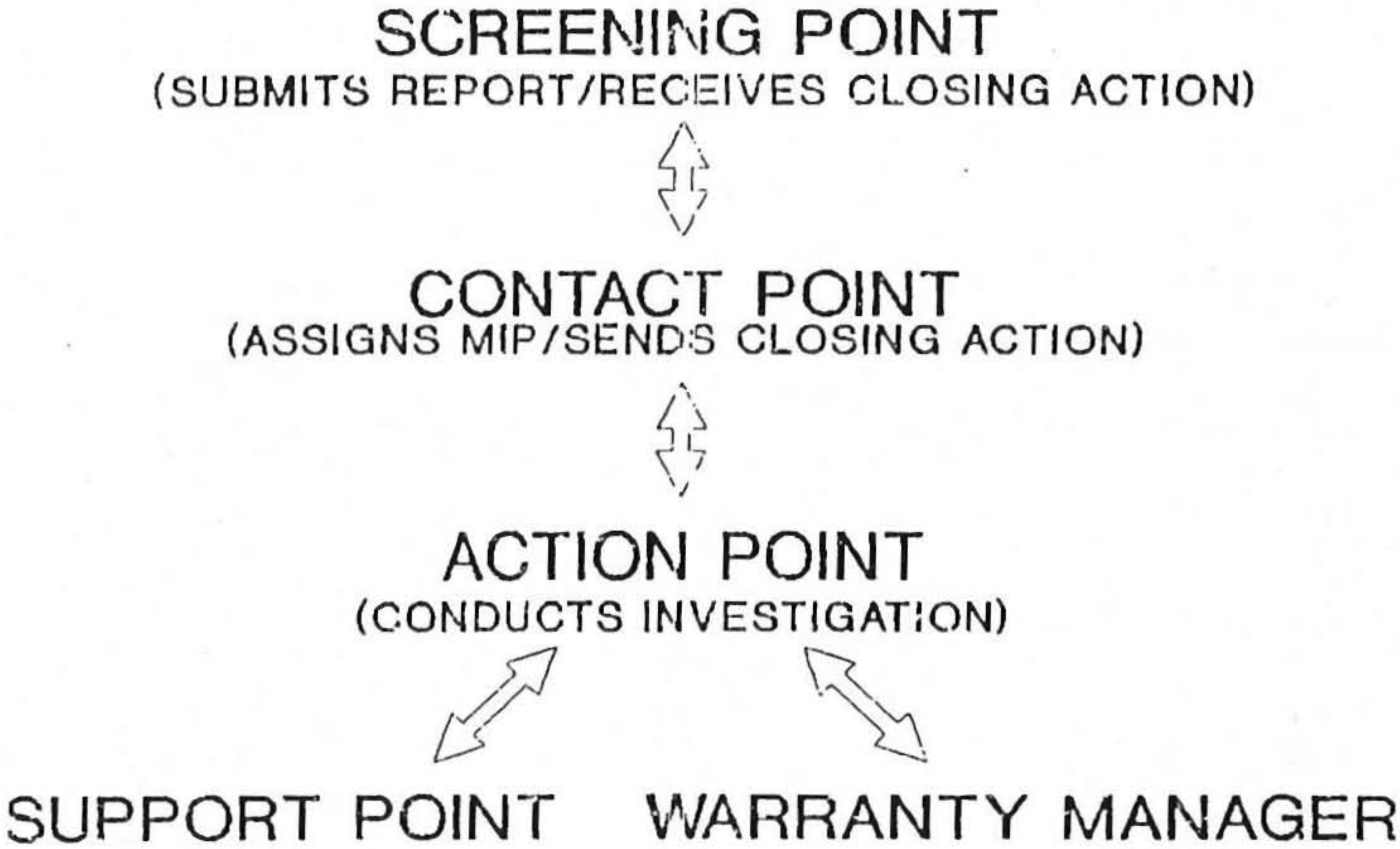

Figure 4. Dull Sword Investigation Process

inflight vibrations (23; 25; 26; 28; 29; 30; 33). The NRIU was originally designed to be in use approximately five percent of an aircraft's total flight hours with it being removed from the aircraft when it was not being used (27; 30; 33). However, F-16 units have been leaving them installed on the aircraft for almost all flights citing that it is impractical and time consuming to remove it when it is not being used (23; 26; 27; 30). Thus, the NRIUs are being exposed to a significantly higher amount of inflight vibrations than originally conceived, even though they are not being electronically used for their intended purpose. Solving the vibration problem has not been easy and is still being worked by systems engineers. It is complicated by the fact that the vibration environment that the NRIU must endure is highly dependent on what is loaded on the F-16 and at what altitudes it is flown (30). As the F-16 program has matured, numerous types of munitions, fuel tanks, and pods have been added to the list of items that an F-16 can carry. Each item or combination of items creates different vibration environments that must be considered when designing a more reliable replacement NRIU. A "more ruggedized" NRIU has been designed, but it is still being tested and modified (23; 24; 25; 26; 29; 30; 33). Even once the new NRIU is fully developed it will still take time to be produced and distributed to F-16 units. This example shows that a Dull Sword/MIP investigation can take up to several years to complete.

Dull Sword Controversies. There are several misconceptions that can adversely affect the intent of Dull Sword reporting that need to be considered. This section addresses some of the managerial implications that may be barriers to the Dull Sword reporting system.

One belief is that units avoid reporting Dull Swords because they are basically "bad news". Reporting a Dull Sword is perceived as airing dirty laundry (4; 6; 21; 22; 24). As stated earlier, Dull Swords are reported to bring problems to the immediate attention of agencies which can evaluate them and correct them if necessary (10:80). Dull Swords are also reported to like units so that they can evaluate the possibility of a similar occurrence at their unit. A unit discovering a nuclear safety deficiency may be able to develop corrective actions locally or may be able to get by without reporting a Dull Sword, however doing so would circumvent the intent of the Air Force Nuclear Surety Program (10:80). The action agencies would not be made aware of the problem and could construe "no news as being good news" (23; 25; 26; 28; 33). Similar units would not be looking for the same deficiency to occur and may not be taking proper preventative actions (4; 6; 21; 22; 24; 28; 33; 34). Probably the most serious consequence of failing to report a deficiency would be a nuclear accident or a significant nuclear incident. The unit that did not report the Dull Sword may not have felt that the deficiency was serious, but given the circumstances that may or may not be possible at their unit, that deficiency could cause a serious problem somewhere.

Units should realize that Dull Swords are not "bad news" nor should command reporting channels treat them as such. In fact, reporting Dull Swords is vital to the Nuclear Surety Program. Dull Swords are "limited use reports" which have special disposition instructions to ensure that they can not be used adversely against the reporting unit (10:85; 27). It is the limited use requirement that prevents the author from identifying the units submitting Dull Swords cited in this thesis.

Another misconception is that once a deficiency has been reported several times it is not necessary to report subsequent like failures (4; 6; 21; 24; 26: 30: 33). It is believed that some units may not be reporting NRIU Dull Swords for this reason. Units may feel that is is a waste of time and effort to continue reporting such failures. There are two main reasons why this philosophy should not be followed.

The first deals with the sheer number of deficiencies reported. For the action point to place the right amount of emphasis on a deficiency they must know the extent to which it is occurring. This is accomplished primarily through trend analysis (23; 25; 26; 27; 28; 33). For example, if a deficiency has been repeatedly occurring at units, but only a few Dull Swords being reported, the action point will not know the "true picture" which may warrant the expense of a

Material Improvement Project. Like all Air Force agencies, the action points are limited by manning and budget constraints and must be able to justify their efforts. Trend analysis also comes into play when the action points must justify the high costs of fleetwide system modifications (23; 28; 30; 33). For example, for the action point to justify the high cost of developing and procuring a new NRIU, they had to demonstrate to higher headquarters the extent to which the NRIU was affecting the F-16 fleet. If only a few Dull Swords had been reported it could have been difficult to warrant the project's high costs.

The second reason why this philosophy should not be followed involves the complexity of modern weapon systems. In computer-intensive aircraft such as the F-16, programming errors in the software can cause hardware such as the NRIU to fail (23; 26; 30; 33). The hardware failure may have the same SRU or subcomponent go bad whenever software errors occur, however it may be a different software error that caused the failure each time. Systems engineers need to know where and when the failures occurred so that they can correct the software. It is almost impossible for the engineers to plan all of the scenarios that can go on inside and outside of the aircraft which may lead to programming errors or procedures being left out of the program. "One should also realize that a computer program partially consists of combinations of "1" and "0" and all it takes is one of them to be in the wrong place or one of them to be left out to cause a failure" (33). However, it may take a certain scenario to occur for that error to cause a hardware failure. Such errors are still being found in the F-16 A/B aircraft, which have been in the active inventory since the late 1970's (33). Therefore, it is important for units to continue to report Dull Swords on these components.

Computer Products

Computer products were obtained from two sources: the F-16 Central Data System (CDS), also referred to as TICARRS (Tactical Interim CAMS and REMUS Reporting System), and the Directorate of Nuclear Surety's (DNS) AID data file. This section explains these sources and the reports retrieved from them.

Central Data System. CDS is an integrated data collection system developed for use with the F-16 weapon system, which includes engineering, configuration, and logistics data. It provides up-to-date and accurate F-16 related data to personnel who require it to support the weapon system and to provide a central source where data from operational bases is consolidated and made available to Air Force units and agencies. Its main objective is to provide information to the System Program Office and AFLC to help manage the F-16 aircraft, Avionics Intermediate Shops (AIS) test sets, and selected support equipment. Additional objectives are to reduce or simplify the paperwork for maintenance personnel at all levels and to increase troubleshooting/maintenance action efficiency by readily providing related maintenance historical data (1; 17:2-1, 2-2; 20).

Data are collected primarily by the use of on-line terminals located at maintenance activities, which replace the majority of the manually completed paper forms and the subsequent keypunching of the data on those forms. Printers provide hard-copy outputs of any requested data or information. Data are entered into the system by "calling-up" a screen and keying in the required information. When the user completes the screen, all information is validated by the computer to prevent obvious errors. When errors are found, an error message is displayed on the screen so that the user can make corrections (17:2-1, 2-2).

At the operating bases, terminals are installed in the pilot debrief and aircraft maintenance support areas within the aircraft maintenance units (AMU). As flights depart, the debriefer enters the basic flight profile into the system. When the pilot returns from the mission, the flight profile is recalled from the system and debriefing information is entered into the profile. Such debriefing information would include aircraft problems/discrepancies that occurred during the mission. For each discrepancy reported on the profile, a facsimile AFTO form 349 (maintenance work order) is printed to dispatch maintenance personnel. This use of automation is intended to simplify the workload of the debriefer so that he/she has time to enter more accurate descriptions of discrepancies into the system. Upon completion of the maintenance actions, maintenance personnel call-up the partially completed AFTO 349 by job control number and enter the corrective actions in the appropriate blocks on the screen. After all corrective actions for the specified job control number have been completed and entered into the system, the AFTO 349 is considered complete pending supervisory approval. AMU supervisors can query/review the status of each AFTO 349 at any time during a shift and may add information to them, if necessary. The status of each AFTO 349 can also be monitored by personnel in the maintenance control center via a terminal and printer that are installed there (1; 17:2-1 through 2-3; 20).

The CDS also collects all information on maintenance performed at the AIS test stations in a slightly different manner.

> Each maintenance action is recorded by calling-up the appropriate conversation and entering the data. Some conversations are used to log maintenance against the aircraft line replacement units (LRU) by serial number, part number, or work unit code, other conversations are used to log maintenance against the test station LRUs also by serial number, part number, or work unit code. The recording of maintenance actions in these conversations requires technicians to enter all required data on the appropriate screen. The data is considered complete pending supervisory approval (17:2-3).

A major strength of CDS is that it tracks each aircraft discrepancy from the time it is entered into the system by the debriefer to the time the faulty LRU is repaired by the AIS. For example, if an NRIU failed in flight, the pilot would describe what occurred and the debriefer would enter the discrepancy into the system. Next, armament specialists would be dispatched to troubleshoot the aircraft via the computer printed AFTO 349. The specialists would diagnose the problem using the aircraft's built-in-tests. Normally, a maintenance fault listing (MFL) indicating that the NRIU was at fault would appear on the aircraft's multifunction display. They would then enter a description of their findings and the MFL that occurred into CDS and would also indicate the work unit code, the serial number of the suspect NRIU, and he aircraft from which the NRI was removed. Next, the NRIU would be taken to the armament shop to be tested on the Dash 500 armament test set. The findings of the test, whether the NRIU passed or failed, would then be entered into CDS. Next the NRIU would be sent to the AIS for more indepth testing. After testing the unit, the AIS technicians would enter the test results into CDS indicating the tes that was made, the step of the test that the NRIU failed, and t.e numerical display values of the fault indicated by the test set. The AIS would also enter a descripti n of the repairs made, and when possible, would enter the wo unit code of any subcomponents or service replacement units (SRUs) that were replaced. As troubleshooting is accomplished, each technician/shop has access to all of the previous troubleshooting information on the failure via CDS. This expedites the flow and increases the accuracy of necessary information throughout the maintenance process, which allows for more efficient use of resources (1; 20; 25; 26).

CDS can output data in several formats. It can give data on simulated Air Force forms such as the AFTO 349. It gives detailed data listings from the central computer files that help support ongoing maintenance and supply management activities. These formats include failure history reports in chronological order for specific job control numbers aircraft, or work unit codes. CDS can also give data outputs in tabular or graphic forms. Additional output capabilities are made available to units enrolled in the CDS time-share program, where units can design and program their own output reports. To obtain a CDS output, the user simply specifies the subject of interest, a time span, and any other relevant conditions (i.e. work unit codes or part numbers) into a specified computer program (1; 17:2-4; 20). Units can also access historical information concerning all units by querying the CDS central data file.

CDS does have some drawbacks. The major complaint, as with all automated systems, is that the system will only output information that is as accurate as the information that is put into the system (1; 2; 20; 23; 26; 31). For example, if the debriefer enters a shallow description of the problem into the system, the armament technicians may have to contact the pilot to see what went wrong in flight or accomplish extra tests to try to find the fault. If subsequent information that is entered into CDS during troubleshooting is also shallow, the whole maintenance process can be hindered by the lack of accurate information being given to technicians. Additionally, when personnel at the systems program office or the air logistic centers review CDS outputs to determine whether or not problems are occurring at operational units, they will have little information to base decisions upon. For example, if the description of the fault simply states the NRIU failed inflight, the systems engineers would need additional information to base decisions. What was the pilot doing at the time of the failure? Did any other failures occur at the same time? Did the NRIU pass on the armament shop's test set? What were the specific test results at AIS? What repairs were made (1; 23; 26; 27; 29; 30; 33)? As one can see, the system is capable of storing this important information, but it must be entered by the operational units.

A second drawback of using CDS is that it is gradually being phased out of use and being replaced by CAMS (Core Automated Maintenance System) and REMUS (Reliability and Maintainability Information System) (1; 19; 20). CAMS is instituted at units in the same manner as CDS, but it is considered to be easier to operate. The input/output process is the same as in CDS, however the formats differ. A limitation of CAMS is that historical information is only available for the unit requesting information because CAMS will not be tied into a central data base such as the CDS until REMUS is instituted in the early 1990s (1; 19; 20).

DNS AID Data File. The AID data file is maintained in a mainframe computer at DNS. Historical information is stored on all AID reports dating back over the past 20 years. The file tracks the curren status of each report from the time a deficiency is reported to the time the final closing actions are made. The system has over 40 screens of information available and is capable of sorting reports by numerous methods such as: by unit; by control number; by type of deficiency; by time of year by work unit code; and by key information or words that may appear in narratives. The system is also capable of handling classified information. Outputs of the system are available to any Air Force units or agencies that have a valid need for the information, b the protective provisions of "limited use information" in accordance with AFR 127-4 must always be adhered to (27).

III. Methodology

Overview

This chapter describes the methodology used to answer the research objectives stated in Chapter I. The methodology lists the research instruments used, the manner in which these instruments were used, along with a justification for applying these instruments in this study.

Due to the nature of the subject and the limited sources of information available, this study did not lend itself to statistical analysis. As a result, interviews, literature reviews, and available computer products were used to develop and support its findings.

Research Instruments

The primary research instruments used to gather analysis information consisted of: (1) interviews of experts involved in each aspect of Dull Sword reporting; (2) a literature review of applicable regulations, manuals, and technical orders; and (3) a review of computer reports from the F-16 Central Data System (CDS) and the Directorate of Nuclear Surety's (DNS) Nuclear Accident/Incident/Deficiency (AID) Data File.

Interviews. Unstructured personal and telephone interviews were used to gather information. Experts in each area of the Dull Sword reporting system, the F-16 Aircraft, and/or available computer products were interviewed. The persons contacted included the following: personnel involved in investigating, reporting, and/or analyzing Dull Swords at the Directorate of Nuclear Surety (DNS), HQ USAFE, HQ TAC, HQ PACAF, HQ AFLC, and HQ ASD; F-16 systems engineers at DNS, ASD, and General Dynamics; and computer analysts at DNS and ASD.

The use of unstructured interviews presented some advantages which were beneficial to this study. The main strength was that "They can be used to explore areas where questions are difficult to construct and to probe those interviewed using funneling techniques" (32:289, 290). Borg and Gall stated that one of the main advantages of personnel interviews, in lieu of questionnaires, is that interviews usually permit much greater depth than other methods of collecting research data since the interviewer can alter the questioning during the interview according to the responses given by a subject. They also believe that respondents are more likely to divulge more information during an interview rather than on a questionnaire (2:211-212).

In Walizer's book, Research Methods and Analysis, Emory stated that three broad conditions must be met to have a successful personal interview: "They are: (1) availability of the needed information from the respondent; (2) an understanding by the respondent of his/her role; and (3) adequate motivation by the respondent to cooperate" (32:161). Emory added that developing a good rapport with the respondent, before the interview, would assist in establishing these conditions (32:162).

Failure to maintain Emory's three conditions presents some disadvantages to personal interviews. Borg and Gall believed that the interpersonal situation may lead to subjectivity and bias (2:213). Emory stated:

> "That there are many unknown reasons for bias during interviews that are subject to a large number of studies. However, many of the findings of these studies are at odds with exact dimensions of bias and the conditions under which it occurs. In light of this confusion, the safest course for researchers is to recognize that there is a constant potential for response error (32:167).

Literature Review. A thorough literature review was accomplished on nuclear surety program requirements, Dull Sword Reporting, and maintenance data collection. Applicable USAF technical orders and regulations were reviewed to gain a working knowledge of the subject and associated problems. Contractor manuals for the F-16 Avionics System which includes the MUX AMAC, and on the F-16 Central Data System (CDS) were also reviewed. Due to the nature of this subject and the lack of previous research on it, no applicable information was found through the Defense Technical Information Center (DTIC) and DIALOG literature searches.

Computer Products. Three computer reports were compared and analyzed. These reports were: The "Maintenance History Report" from the F-16 CDS and the "Oneliner" and "Background" reports from the DNS AID data file.

Research Methodology

This sec ion provides the methodology used to analyze the three research objectives posed in Chapter One.

Objective One. "Develop a more specific definition of Dull Swords for the F-16 and/or provide better reporting guidance." To research this objective, failure data were obtained using personal interviews and computer products on the major F-16 C/D MUX AMAC components. These components included the following:

1. Advanced Central Interface Unit (ACIU)
2. Enhanced Fire Control Computer (EFCC)
3. Nuclear Remote Interface Unit (NRIU)
4. Jettison/Release Remote Interface Unit (J/R RIU)
5. Multifunction Display Set (MFDs)
6. Program Display Generator (PDG)
7. Nuclear Consent Switch (Panel)
8. Master Arm and Release Relay Matrix Assembly
9. Matrix Assembly for Station 3
10. Matrix Assembly for Station 4
11. Matrix Assembly for Station 5
12. Matrix Assembly for Station 6
13. Matrix Assembly for Station 7

The num[illegible] us wiring harnesses that connect these components were not considered in this study.

As a minimum, the SMS experts were asked the following questions about each component to help determine when Dull Swords should be reported on failures:

(1) Would the failure of this component affect nuclear safety?

(2) In what situations would its failure affect nuclear surety?

(a) Would failures affect nuclear safety only when the nuclear mode is being used or tested?

(b) Would failures occurring during other modes (i.e., air-to-air) affect nuclear safety?

(3) What symptoms would indicate that this component failed (i.e., would a maintenance fault listing (MFL) occur)?

(4) Are there subcomponents or Shop Replacement Units (SRU) that are unique to the nuclear mode? If so, can these components be identified by work unit codes (WUC)?

The opinions of each expert were then compiled to establish when Dull Swords should be reported on each component. The opinions were then verified with the nuclear weapons systems analysis engineer at DNS. In the event of conflicting expert opinions, the DNS engineer's opinions were used because of his expertise in both the MUX AMAC system and USAF Nuclear Surety policy. Where possible, actual Dull Sword reports provided by DNS were used to validate these opinions. This information was then used to derive better guidance on reporting Dull Swords.

Objective Two. "Determine if a representative number of Dull Swords are being reported by F-16 units." To accomplish this portion of the study, the guidance/revised definition developed in objective one was used in conjunction with computer products. The actual Dull Sword reports for the period of 1 January 1988 to 30 June 1988 were compared to the CDS maintenance history reports on each component for the same period. This method was used to determine whether more failures were occurring at units than were being reported.

Objective Three. "Determine whether there is a better method of reporting Dull Swords or a method available to improve the current reporting system." Accomplishing this portion of the research involved using interviews and then analyzing the CDS computer products. SMS engineers were questioned on what types of information were needed to analyze a component's failure. Numerous CDS products were then analyzed to consider if this information was already available and to see what changes might be necessary to include the needed information.

IV. Findings and Discussion

General

This chapter consists of three sections. Each section discusses the findings corresponding to each of the three research objectives.

Research Objective One

The first objective of this research was to "develop a more specific definition of Dull Swords and/or provide better reporting guidance". Ideally, most Nuclear Surety Officers (NSOs) would prefer to have an all-inclusive list of items/ situations that require Dull Sword reporting and eliminate the subjectivity of their determinations (4; 6; 21; 22; 23; 24; 25; 26; 28; 30; 33; 34). However, this research soon found that creating such a specific all-inclusive list for F-16 Dull Sword reporting was not possible. This was because of the virtually endless hardware/software combinations and use of integrated circuitry in the F-16's multiplex aircraft monitoring and control system (MUX AMAC) (3; 5; 23; 25; 26; 29; 30; 33). Therefore, this research focused on developing better guidance that could be used in making Dull Sword reporting decisions.

The remaining portion of this section addresses the process used in developing reporting guidance. First, general guidance is addressed and then more specific guidance on the F-16's MUX AMAC components is addressed.

General Guidance. The most logical approach was to determine under what conditions a Dull Sword should always be reported. This research first looked at reporting MUX AMAC failures at the systems level and then at the line replacement unit (LRU) and shop replacement unit (SRU) levels.

At the system level, most experts agreed that Dull Swords should always be reported whenever the MUX AMAC or its subcomponents fail while the aircraft is in the nuclear mode (3; 5; 23; 26; 29; 30; 33). While there were some exceptions, which will be discussed later, the current policy is that Dull Swords must be reported on certain situations until further guidance is given by the Directorate of Nuclear Surety (DNS) (33; 34). Such situations include the following: failures occurring while the nuclear system is being tested by maintenance personnel; failures occurring while the aircraft is being used for nuclear training missions; and failures occurring on aircraft loaded with nuclear weapons.

While the limited testing and operation of nuclear capable components makes deficiency reporting doubly important, several experts expressed concern that failures that could not be duplicated (CND) may not be getting reported. These failures are just as important as those that can be isolated by F-16 units and must therefore be reported (3; 23; 26; 29; 30; 33).

It is estimated that the Air Force average for flying F-16s in the nuclear mode is only five percent of the fleet-wide flying hours (23; 27; 30; 33). Since the nuclear system is getting such limited use, it is important to report all failures that occur during this mode. In these situations the system engineers can be certain that the F-16's hardware and software are being used in the nuclear mode. To accomplish their investigations, engineers must know what the hardware and software were doing at the time of the failure, since software problems can cause hardware failures. In many cases the software that caused hardware failures would not have been used in the nuclear mode. Thus, nuclear safety would not have been affected had there been a nuclear weapon on the aircraft (23; 26; 29; 30; 33).

As mentioned previously, it is difficult to assess failures occurring during non-nuclear modes as being Dull Swords. Failures that occur during other modes that could affect nuclear safety should be reported, but they require expertise and judgement at F-16 units (33). If units were to report all MUX AMAC failures as Dull Swords, the reporting system would become overburdened with investigations and reports that do not affect nuclear safety (4; 21; 22; 23; 24; 25; 26; 27; 28; 29; 30; 33). The CDS analysis, which will be discussed later, identified 1356 MUX AMAC component failures that occurred during the first six months of 1988.

At the LRU level, similar reporting logic is used. Dull Swords must be reported on component failures whenever the aircraft is in the nuclear mode (33). The decision process can be simplified slightly since two of the MUX AMAC LRUs are unique to the nuclear mode. Both the NRIU and the nuclear consent panel/switch are dedicated to performing nuclear missions, therefore Dull Swords must be reported each time these items fail (33).

At the SRU level, it was hoped that there were certain LRU subcomponents that were dedicated or vital to the nuclear mode. This would simplify the decision process by identifying these SRUs so that Dull Swords could be reported. For example, if a certain circuit card of an LRU is dedicated for use in the nuclear mode, which was the case with a circuit card in the F-16 A/B central interface unit, a Dull Sword would be reported each time that circuit card failed. Unfortunately, no such SRU was found to exist in the F-16 C/D.

MUX AMAC Components. This section analyzes each of the MUX AMAC components identified in chapter one to determine better guidance on when to report Dull Swords on failures.

Advanced central interface unit (ACIU) experts agreed that Dull Swords should always be reported when the unit fails in the nuclear mode and that it was difficult to establish a blanket policy specifying when to report Dull Swords on failures that occur in other modes (29; 30; 33). The experts did agree on two situations that a Dull Sword should be reported. The first situation would occur when the ACIU generates random fire commands, because such a fai re could cause an armed weapon to be released inadvertently. The second situation would occur if the ACIU failed totally. Such a failure would normally indicate a hardware problem with the ACIU that was not caused by software.

The enhanced fire control computer (EFCC) was a source of controversy among the experts. Two experts felt that EFCC failures should not be reported during any mode because there are so many checks and cross-checks built into the software that it would be impossible f r an EFCC failure to affect nuclear safety (23: 29).

Another expert believed that since the EFCC's role begins so late in a nuclear mission, safety is no longer a factor. This is because the EFCC calculates the weapon trajectory for a given delivery profile (i.e. pop-up or dive toss). In the automatic release mode the pilot concentrates his efforts on flying the aircraft according to the delivery solution given to him by the EFCC. When the aircraft reache the optimum point of the solution, the EFCC gives the release signal and the weapon is released automatically. In the manual release mode the EFCC has the same function except that the pilot gives the release signal when the EFCC tells him via the multifunction and/or heads-up display that the aircraft has reached the optimum release point (30).

The recommended policy for reporting Dull Swords on the EECC as directed by the Directorate of Nuclear Surety (DNS) is to report all failures that occur during the nuclear mode and any other situations where the experts at F-16 units believe that nuclear safety is affected. The rationale for this is that "no matter how infallible a computer program is believed to be, programming errors can still be made" (33).

The nuclear remote interface unit (NRIU) was also a source of controversy. All experts agreed that NRIU failures meet the requirements for Dull Sword reporting (23; 26; 29; 30; 33). However, all but one of them felt that there was no benefit possible from requiring units to continue to report NRIU failures (23; 26; 29; 30). This was because so many Dull Swords have been reported on NRIU failures that they are fully aware of the causes of the failures and already have a new NRIU under development. Nonetheless, DNS's policy on reporting NRIU Dull Swords is that all failures must continue to be reported since the NRIU performs a "critical" nuclear safety function. Therefore, no chance can be taken in possibly missing a type of failure that has not been reported previously (33).

The jettison/release interface unit (J/R RIU) was not a source of controversy. Experts agreed that all failures occurring in the nuclear mode should be reported as Dull Swords (23; 29; 30; 33). However, the determination for non-nuclear mode failures requires a judgement to be made at the F-16 unit discovering a failure. Units must examine the problem in light of the following: if there had been a nuclear weapon on the aircraft when the failure occurred could something bad happen to the weapon? If the answer is yes, report a Dull Sword. An example of such a failure would be the discovery of stray voltage in the J/R RIU (23; 33).

The program display generator (PDG) and the multifunction displays (MFDs) were also the source of some controversy. Two experts believed that Dull Swords should not be reported on any failures of the PDG or MFDs for three reasons. First, there are so many checks and cross-checks in the computer software that it was highly improbable they would degrade nuclear safety. Second, since the MFDs are redundant, as long as one of them is functioning the mission is not affected. Third, the component's function is to display information to the pilot. Since the pilot can easily tell when erroneous information is displayed, the worst that could happen is the pilot would not know what is loaded on the aircraft (29; 30). The DNS's policy on reporting Dull Swords on these components is to report all failures that occur during the nuclear mode and in any situations where the discovering unit determines that nuclear safety is affected. The reasoning for this is similar to that used for the EFCC, that computers are not infallible (33).

All experts agreed that Dull Swords must be reported on failures of the nuclear consent panel/switch. It is dedicated for the nuclear mode and it performs a "critical" nuclear safety function (23; 29; 30; 33).

The experts also agreed that Dull Swords should be reported on matrix assembly failures that occur during the nuclear mode (3; 23; 29; 30; 33). However, it is very difficult to determine if failure in other modes would affect nuclear safety. These situations must be investigated by the F-16 units who must decide on a case-by-case basis which failures to report based on their expertise and the facts surrounding the failure.

Research Objective Two

The second objective of this thesis was to "determine if a representative number of Dull Swords are being reported by F-16 units." This portion of the study was accomplished by comparing two computer products: a central data system (CDS) maintenance history report on each of the MUX AMAC's LRUs mentioned previously and a summary of each Dull Sword submitted on F-16 C/D aircraft provided by the DNS AID data file. The periods of both computer products was from 1 January 1988 to 30 June 1988. Data for F-16 C/D units that do not use the CDS system were eliminated from both computer products. These units were the 39th Tactical Group, the 58th Tactical Fighter Wing and the 432nd Tactical Fighter Wing.

The CDS Maintenance History Report (Table 1) provided maintenance troubleshooting information on each of the LRUs.

W-U-C	DISCREPANCY	W D	H-M	A T	CORRECTIVE ACTION	U P	ACFT	T E	JOB-NBR	DAY	S/N FAILED/ S/N REMOVED	SERIAL # INSTALLED	WC BASE ID
75DFG		F	290	P	REMOVE NRIU. NEW NRIU TO BE ORDERED	1	1A9999-C		0682771	068	81755C1225		RAMS-1G
75DFO	FAILS W-7 LONG TEST TRUBLESHOOT PYLON (AIS)::UNIT FAILING TEST NUMBER 6 AT STEP 190150.	F	290	C	REPLACED RELAY K14. B/C/S.	0	1A9999-C		0682771	068	81755C1223		RAMS-1R
75DFO	NUCLEAR PULSE LOAD DUE	Q	799	1	C/W	1	841244-C		0697210	069			SHAW-2G
75DFO	FAILS ELEC CK ON 16U75J00-883 TESTER	F	799	6	B/C-P.A.T. C-N-0 B/C/S	1	2A9999-C		0717755	071	81755C0655		SHAW-2R
75DFO	REMOVE NRIU FROM PYLON FOR CDS UPDATE	F	290	P	C/W	1	1A9999-C		0723000	072	81755C13C5		RAMS-1G
75DFO		F	290	C	RAN ON TEST STATION, FAILS TESTS 6,9, 10. ORDERED A TRANSCEIVER CCA.	0	1A9999-C		0723000	083	81755C13C5		RAMS-1R
75DFG		F	255	1	UNIT FAILS DIAGNOSTIC TESTING. REPLACED ALL SRU'S NO HELP. PROBABLE CHASIS SHORT. NRTS-1.	1	1A9999-C		0723000	133	81755C1305		RAMS-1R

Table 1. Sample CDS Maintenance History Report

Column one indicates the work unit code (WUC) of the item that was worked on, which normally consists of five characters. Column two describes the discrepancy that occurred or the work being done to repair the unit. Column six gives a description of what was accomplished during troubleshooting. Column eight identifies the aircraft tailnumber. Column ten lists the job control number of the maintenance action. Column eleven gives the date that the maintenance action was completed. Columns twelve and thirteen provide the serial numbers of the components that were removed or installed. Column fourteen gives the base at which the maintenance was accomplished and column fifteen indicates which maintenance shop accomplished the action. Columns three, four, five, seven and nine provide additional information that is not applicable to this research.

The history report gives a chronological history of the discrepancy from the time the discrepancy was first reported to the time it is corrected. For example, in Table 1 the maintenance history is given for WUC 75DFO, the code for a NRIU. The first entry indicates that the NRIU failed when armament shop technicians functionally checked the aircraft's nuclear mode (this is assumed since the armament personnel are responsible for accomplishing the W-7 Long Check). The avionics intermediate shop (AIS) technicians (indicated by an "R" in column fifteen) tested the NRIU and could not duplicate the malfunction (indicated be "CND" appearing in column six).

The DNS AID data file report consisted of two parts. The first part was a "Oneliner" report, which gave a chronological listing of the Dull Swords that were reported by F-16 units. It indicated which base submitted the Dull Sword, the WUC of the defective LRU, and a one line description of the failure. The second part gave an indepth description of each of the Dull Swords appearing on part one.

The first step of the comparison was to analyze the CDS maintenance history report on each LRU to determine which failures or suspected failures met the guidelines established in section one. This was accomplished by reviewing the maintenance technician's description of the discr pancy and description of the corrective action to try to determine whether the failure occurred while the aircraft's nuclear mode was being used. Several key entries in these columns helped this process. First, the research discovered that several stores management set (SMS) maintenance fault listings (MFLs) could only occur when the nuclear mode was in use. These MFLs were SMS MFLs 119 through 128 which indicate a failure of the NRIU and SMS MFL 070 which indicates that a faulty release signal is present in the system (26; 30). Second, key words and phrases were looked for which would also indicate that the nuclear mode was used. For example, one entry indicated that the aircraft failed to drop a BDU-38 and another entry indicated that the aircraft failed to drop a MK-106. Since both items are bomb dummy units that are only used to simulate nuclear weapons on training missions it was concluded that the nuclear mode was in use. Third, failures of the NRIU and nuclear consent switch were easily analyzed since these items are unique to the nuclear mode.

As the analysis was accomplished several weaknesses were found in the CDS history report. First, it was evident that many entries lacked sufficient detail to determine whether or not the nuclear mode was in use. While some bases gave indepth detail of the discrepancies and corrective actions, others gave little or no detail. This confirmed a problem common to all automated systems; that the CDS system can only be as accurate as the information that is entered by the units. Second, several units did not properly use work unit codes. For example, one unit identified the ACIU work unit code 75DJO, as being the cause of almost every SMS fault. They should have used a three-character WUC, 75D, that would indicate the failure occurred somewhere in the SMS. The WUC for the ACIU should only be used when the ACIU is suspect for the actual failure (1; 20). As a result, the ACIU was improperly identified in CDS as the cause of other SMS failures. Third, several units used non-standard abbreviations in their descriptions. This made it difficult to determine what actions were actually accomplished at these units.

The second step was to identify whether the Dull Sword reportable situations discovered in the first step were reported. This was accomplished by comparing the two computer products by F-16 unit, type of failed component, time of occurrence. Whenever possible, this was accomplished by component serial number.

Findings. This section discusses the findings of the analysis. The findings concerning each of the MUX AMAC components are addressed separately.

Five Dull Swords were reported on the ACIU by units that currently use CDS, with an additional one being reported by the 39th Tactical Group. A total of 891 ACIU maintenance actions were reported in CDS of which 531 involved troubleshooting/repair of ACIUs. The remaining actions included: the removal and replacement of ACIUs for unspecified reasons; the removal of ACIUs for other maintenance actions; the removal for updating the software program; and actions erroneously attributed to the ACIU. Of the 531 failures, only three could be confirme as Dull Swords. In each of these cases, MFL Ø7Ø appeared in the description of the discrepancy and the corrective action required the repair or replacement of the ACIU. None of these failures were among the five Dull Swords reported. The remaining CDS entries lacked sufficient detail to determine whether the nuclear mode had been used. If five percent (which is the estimated portion of F-16 flights in the nuclear mode given previously) of the 531 had occurred in the nuclear mode, 27 Dull Swords should have been reported by the units in this study. Since only five Dull

Swords were reported with three confirmed Dull Swords not being reported, the evidence indicates that a representative number of Dull Swords on the ACIU may not have been reported by F-16 units.

Seven Dull Swords were reported on the EFCC by units using CDS with an additional one reported by the 39th Tactical Group. A total of 917 maintenance actions were reported in CDS of which 454 involved suspected or actual EFCC failure. Many of these failures could not be duplicated. The remaining CDS entries involved the removal and installation of EFCCs for unspecified reasons or the removal for other maintenance. Of the 454 entries, two contained sufficient information to determine that Dull Swords occurred. In both cases there were multiple failures of the SMS which resulted in the EFCCs and the NRIUs being replaced. Since NRIUs were involved, it could be safely assumed that the aircraft were in the nuclear mode when the failures occurred. Neither of these incidents were reported as Dull Swords. Further, if five percent of the 454 EFCC failures occurred in the nuclear mode approximately 23 Dull Swords should have been submitted. Since only seven Dull Swords were submitted on EFCCs and two additional confirmed Dull Swords were not submitted, it is possible that units are not reporting a representative number of Dull Swords on the EFCC.

Sixteen Dull Swords were submitted on NRIU failures, with an additional report submitted by the 39th Tactical

Group. A total of 177 maintenance actions were reported in CDS on the NRIU. Thirty-four of the entries met the requirements of a Dull Sword in that either the NRIUs failed or the NRIU failures could not be duplicated. This led to the conclusion that over 50 percent of the Dull Swords involving NRIUs were not reported by F-16 units. Therefore, a representative number of Dull Swords on the NRIU were not reported.

No Dull Swords were reported by F-16 units on the J/R RIU. Sixty maintenance actions were reported in CDS with 25 of them being failure related. There was insufficient evidence to determine whether any of the failures occurred in the nuclear mode or that any of them affected nuclear safety. If five percent of the failures occurred in the nuclear mode, one Dull Sword should have been reported. Therefore, there was little evidence indicating that units were not reporting a representative number of Dull Swords on the J/R RIU.

No Dull Swords were reported on the MFDs. One hundred thirty-one maintenance actions were reported in CDS with 125 of them involving failures. None of the failure descriptions contained evidence that the failure occurred in the nuclear mode and only seven of them involved dual MFD failures. If five percent of the failures occurred in the nuclear mode, approximately six Dull Swords should have been reported. Therefore, there was some evidence that units may not be reporting a representative number of Dull Swords on the MFDs.

No Dull Swords were reported by F-16 units on the PDG. Three hundred ninety-four maintenance actions were recorded in CDS with 174 of them involving failures. Additionally, 51 of the failures resulted in the loss of both MFDs. There was no evidence that any of the failures occurred in the nuclear mode. If five percent of the failures happened in the nuclear mode, nine Dull Swords should have been submitted. Therefore, it is possible that units are not reporting a representative number of Dull Swords on the PDG.

No Dull Swords were reported on the nuclear consent panel/switch and no maintenance actions were reported in CDS. Consequently, there was no evidence whether units were reporting a representative number of Dull Swords on this component.

No Dull Swords were reported on the matrix assemblies. Thirteen maintenance actions were reported in CDS with all of them being failure related. One of the failures could be confirmed as occurring in the nuclear mode since both the station 3 matrix assembly and an NRIU were troubleshot for causing the failure. In this case the failure was caused by a defective matrix assembly and a Dull Sword should have been reported. In conclusion, there was some evidence of a problem in reporting a representative number of Dull Swords on matrix assemblies.

Table 2 gives a summary of the findings of this section. Column one identifies the MUX AMAC component. Column two lists the number of component "failures" that occurred according to the CDS maintenance history report. This number does not include other maintenance actions on the components. Column three gives an estimated number of Dull Swords that should have been reported if five percent of the failures occurred in the nuclear mode. Column four indicates the number of Dull Swords that could be confirmed using the CDS report. Column five lists the number the Dull Swords that were identified by CDS (column four) that were actually reported as Dull Swords. Column six gives the number of Dull Swords reported. Column seven identifies the number of actual Dull Swords that should have been reported. It should be noted that if the five percent assumption proved to be invalid, the analysis would still show that 47 percent (24 out of 52) of the actual Dull Swords were not reported.

Research Objective Three

The third objective of this thesis was to "determine whether there is a better method of reporting Dull Swords or a method available to improve the current reporting system". It had been suggested that reporting of Dull Swords could be improved by using an existing maintenance data collection system such as CDS to automatically identify those situations which meet the requirements of a Dull Sword and

Reporting System Effectiveness						
Compt 1	Total Failures Rptd in CDS 2	Estimated DS 3	Confirmed DS in CDS 4	CDS DS Reported 5	Total DS Reported 6	A[illegible]ual DSs 7
ACIU	581	27	3	0	5	8
EFCC	464	23	2	0	7	9
NRIU	34	34	34	16	16	34
J/R RIU	[illegible]	1	0	0	0	0
MFD	125	6	0	0	0	0
PDG	174	9	0	0	0	0
Nuc Con Switch	0	0	0	0	0	0
Matrix	13	1	1	0	0	1
Total	1366	101	40	16	28	52

Table 2. Reporting System Effectiveness

then automatically submit a Dull Sword report. An automated system would eliminate the sometimes cumbersome process of investigating and reporting Dull Swords. This research soon concluded that such an ideal system was infeasible at this time. This conclusion was based on two facts. First, the decision to report a Dull Sword is not always simple and often requires human judgement and expertise that cannot easily be programmed into a computer. Second, automated systems are only as accurate as the information entered into them. In the case of CDS, numerous errors and superficial reports were entered that would not provide the necessary information for off-site experts to investigate the failures.

After eliminating the automated approach, this research then focused on looking for a method that could augment or improve the current reporting system. It was found that an automated maintenance data collection like CDS could help simplify the investigative process if maintenance personnel enter all necessary information in the descriptions of the discrepancies and corrective actions (3; 23; 26; 29; 30). If everyone involved in the troubleshooting process entered more detailed descriptions of what they did, it would make it easier and less cumbersome for the NSO and screening point to assemble a Dull Sword report. More accurate data would reduce the time and effort needed to contact the personnel for information, since their actions would already be documented in the system.

V. Conclusions and Recommendations

This chapter includes a short summary of this research project, a listing of conclusions based on the findings presented in the previous chapter, and recommendations for improvement of the Dull Sword reporting process.

Project Summary

The purpose of this thesis was to determine what problems existed for reporting Dull Swords on the F-16 and what could be done to improve the sometimes cumbersome reporting process. The major source of controversy has been that Nuclear Surety Officers and others stationed at F-16 units desired more guidance on reporting Dull Swords, like the guidance which has been available for older weapon systems. The dilemma of what to report has also been complicated by the F-16's multiplexed circuitry and computer hardware/software combinations.

Experts on the F-16's multiplexed arming monitoring and control system (MUX AMAC) were interviewed to determine when Dull Sword reporting was beneficial and when Dull Swords should not be reported. This information was gathered to develop better reporting guidance that could be provided to F-16 units. The expert reporting guidance generated in the first phase of this research was then used in conjunction with two computer products to determine whether units were reporting a representative number of Dull Swords. Finally, a maintenance data collection system computer product was evaluated to determine whether it or similar systems could be used to replace or augment the existing Dull Sword investigation and reporting system.

<u>Conclusions</u>

Conclusions are presented for each research objective.

1. Develop a more specific definition of Dull Swords for the F-16 and/or provide better reporting guidance.

As indicated in chapter four, the expert opinions differed on several situations, however the guidance of the engineers at the Directorate of Nuclear Surety (DNS) was used as the final reporting policy. The reporting guidance issued by DNS requires Dull Swords to be reported on the MUX AMAC components listed in previous chapters each time they fail when the F-16 is operating in the nuclear mode. Additionally, Dull Swords must be reported on these components when they fail in other modes, if based upon their expertise and judgement, the discovering unit decides that nuclear safety was affected. Some examples of these situations were provided along with the decision rationale. Although not all-inclusive, this information provided more definitive Dull Sword reporting guidance for units; therefore, it is concluded that objective one of this thesis was met.

2. Determine if a representative number of Dull Swords are being reported by F-16 units.

Analysis of the Central Data System (CDS) Maintenance History Report and the DNS AID data file report comparisons found that given the new guidance, there did not appear to be a representative number of Dull Swords being reported by units for all MUX AMAC components. The analysis of NRIU failures provided the best evidence of this since over 50 percent of the failures were not reported as Dull Swords. The evidence was not as concrete for other component failures, because it was not possible to determine in which mode failures occurred. In addition, superficial descriptions of discrepancies and corrective actions were discovered in the CDS data. While only eight Dull Swords on these components could be confirmed, none of them had been reported. This indicated that there was a reporting problem at F-16 units, but the extent of the problem is unknown due to weaknesses in the CDS data. If five percent of these failures did occur in the nuclear mode or did affect nuclear safety, it could be concluded that a significant problem existed, but there was no proof to substantiate the five percent assumption.

3. Determine whether there is a better method of reporting Dull Swords or a method to improve the current reporting system.

Initially, it was believed that CDS products could be used in lieu of Dull Sword reports. However, the weaknesses of the CDS system provided evidence that the current automated maintenance data collection systems cannot replace the Dull Sword reporting system. While CDS could be used to identify failure trends and augment Dull Sword reporting, this research found that most entries lacked sufficient detail to determine whether a Dull Sword occurred and lacked the information necessary for engineers to investigate a problem. It was also found that the human expertise and judgement that was necessary to make the more difficult Dull Sword decisions could not be easily programmed into a computer. The research did conclude that the automated systems could be used to augment/streamline Dull Sword investigation and reporting at units, provided more accurate and descriptive information is entered into the system.

Recommendations

General areas of concern were identified as a result of this research, resulting in the following recommendations.

Recommend that the reporting guidance assembled in this thesis be reviewed by DNS and then be distributed to the major command safety and maintenance personnel for dissemination to subordinate units. Table 3 briefly summarizes the current DNS reporting guidance and also includes the recommendations of other experts and this research. Column one lists the MUX AMAC component. Columns two, three and four identify the current DNS reporting policy for each component. Column five gives the opinions of other experts of what they believe should be reported. Column six states the reporting recommendation of this research.

2. Recommend that maintenance personnel enter more specific information into the maintenance data collection

Guidance and Recommendations

Comp	Reporting policy: All	Reporting policy: Nuc Mode	Reporting policy: Unit Judgment	Expert Opinion	Research Recommendation
ACIU		X	X	Use Current Policy	Use Current Policy
EFCC		X	X	Report None	Use Current Policy
NRIU	X			Report None	Review Policy
J/R RIU		X	X	Use Current Policy	Use Current Policy
MFD		X	X	Report None	Use Current Policy
PDG		X	X	Report None	Use Current Policy
Nuc Con Switch	X			Use Current Policy	Use current Policy
Matrix		X	X	Use Current Policy	Use Current Policy

Table 3. Guidance and Recommendations

systems used at their unit, whether CDS or the Core Automated Data System (CAMS). Such information should include: the mode that was being used or tested at the time of failure; the specific discrepancy (i.e. SMS 070 occurred thirty minutes into flight when the pilot was doing...); the correct work unit codes of items suspected of failure; specific information on tests done at the armament shop or at the avionics intermediate shops; and specific information on corrective actions taken. This information could then be provided to the screening point and the Nuclear Surety Officer (NSO) when they prepare a Dull Sword report and eliminate much of the leg work that they must do. It would also help prepare reports on those items that slipped through the reporting system. For example, if a NSO discovered that a Dull Sword was not reported on a NRIU that failed weeks earlier, the information necessary to submit a late Dull Sword report could be retrieved from CDS. If the required information was not in CDS he/she would have to submit a report that simply stated that a NRIU failed for an unknown reason with unknown corrective actions being taken, or not report the failure at all and hope that the error was not discovered by a nuclear surety inspection team.

3. Recommend that the NSO and maintenance personnel work as a team in reporting Dull Swords. They should use the automated maintenance data collection system at their wing in a similar manner as used in this thesis. They should continue to use combined material deficiency/Dull

Sword reporting whenever possible and share the responsibility and workload for investigating and reporting deficiencies. This would ensure that no Dull Swords go unreported by the system and that valuable time of both safety and maintenance personnel is not lost. If possible, units should establish written guidelines in the form of a base regulation or maintenance operating instruction to ensure personnel understand their responsibilities.

4. Recommend that units streamline the report coordination process to accommodate the increased number of Dull Sword reports that could result from implementing the reporting guidance recommended by this thesis or from increased MUX AMAC use, due to mission changes.

5. Recommend that the NSO and other key personnel attend the Weapons System Maintenance Technician AGS/F-16 C,D [illegible]se (J4AMF/ASF/AST462X0-152) taught at units by the [illegible]ning Command's Field Training Detachments (31). [illegible]d help personnel understand [illegible]w the MUX AMAC works, thu[illegible]ng the investigating and reporting process.

6. Recommend that NSOs be given additional training by operations personnel so that they understand the critical sequence of events that must occur in the cockpit during nuclear weapons delivery. This information would help the NSO make Dull Sword determinations

Appendix: Definition of Terms

Abnormal Environment. Those environments in which the weapon or combat delivery vehicle is not expected to retain full operational reliability (12:28).

Action Point. The office within the action point activity that is responsible for the resolution of a deficiency (15:1-2).

Advanced Central Interface Unit (ACIU). The ACIU provides control of the stores management system (SMS) of F-16 C/D by processing and interfering with SMS and system elements (18:3-14).

Air Force Action Point Activity. The activity responsible for resolution of a deficiency. The action point activity will typically be the maintenance engineering management ALC designated in TO 00-25-115. (15:1-2).

Aircraft Monitoring and Control System (AMAC). That equipment installed in aircraft to permit monitoring and control of safing, arming, and fuzing functions of nuclear weapons or nuclear weapon systems (14:2).

Armed. The configuration of a nuclear weapon in which a single signal will initiate the action required for obtaining a nuclear detonation (12:28).

Bent Spear. A significant incident or unexpected event involving nuclear weapons, warheads, or nuclear components which does not fall in the BROKEN ARROW category but:

(1) Damages a nuclear weapon or nuclear component to the extent that major rework, complete replacement, or examination or recertification by the design agency is required.

(2) Requires immediate action in the interest of safety or nuclear weapon security (e.g., render-safe procedures), or which may result in adverse national or international public reaction or premature release of information (e.g., a bonafide attempted theft or seizure of a nuclear weapon).

(3) Has such potential consequence as to warrant the interest or action of officials or agencies outside the Air Force (10:80, 81).

Bomb Dummy Unit (BDU). Unit released from an aircraft that has similar flight characteristics of a nuclear weapon. It is used for training pilots. The most common BDU's are the BDU-38 and MK-106 practice bombs.

Broken Arrow. An accident or unexpected event, except as modified by AFR 127-4, paragraph 10-3b, involving nuclear weapons, warheads, or nuclear components resulting in any of the following:

(1) Nuclear detonation of a weapon.
(2) Nonnuclear detonation or burning of a weapon.
(3) Radioactive contamination.
(4) Loss, theft, seizure, or destruction of a nuclear weapon, warhead, or nuclear component. Loss includes, but is not limited to, intention jettisoning using approved Air Force procedures or inadvertent release of nuclear weapons or nuclear components.
(5) Public hazard; actual or implied (10:80).

Central Data System (CDS). System designed for the F-16 to provide data information relative to measuring aircraft and test station reliability, aircraft and test station maintainability and aircraft operational performance (17:1).

Combat Delivery Vehicle. Nuclear-capable vehicle (such as an aircraft or missile) with its installed equipment, which is used for the combat delivery of nuclear weapons. (Installed equipment includes command and control elements and launch equipment necessary to launch ground launched missiles.) A combat delivery vehicle is operated under approved nuclear weapon system safety rules according to AFR 122-2 (12:28).

Computer Program. A series of instructions in a form acceptable to digitally programmable equipment or a system designed to cause the execution of a sequence of computational (arithmetic or logic) or control operations (15:1-2).

Contact Point. The office within the action point activity which receives, time stamps, controls (assigns Material Improvement Projects (MIPs), if applicable) and performs routing of deficiency reports to the appropriate action point (15:1-2)

Conventional Weapon. A device which gets its explosive power from a nonnuclear reaction.

Credible Accident. A reasonable sequence of environments to which a weapon or weapon system may be exposed that would degrade operational reliability or nuclear safety or both (12:28).

Critical. The use of this term describes functions, circuits, activities, and hardware and software components which control, reverse, or apply directly to the authorization, prearm, arm, release, launch, or targeting functions of a nuclear weapon system. (12:28).

Design Deficiency. Any condition that limits or prevents the use of materiel for the purpose intended or required where the materiel meets all other specifications or contractual requirements. These deficiencies cannot be corrected except through a design change (15:1-2).

Dull Sword. A nuclear safety deficiency; i.e., a situation, event, or condition not reportable as BROKEN ARROW or BENT SPEAR which could or does degrade nuclear safety. Report Dull Sword for the following:

- (1) Damage, malfunction, or failure of a war reserve (WR) nuclear weapon or warhead. Excluded are:
  - (a) Conditions due to wear that are repairable by authorized painting or hardware or seal replacement.
  - (b) Minor nuclear weapon deficiencies where acceptance criteria are provided in technical orders.
  - (c) Non-safety related quality deficiencies noted during receipt or reinstallation inspection of parachute assemblies.
- (2) Exposure of weapon or warhead to unusual or severe environments (flood, earthquake, lightning, and so forth).
- (3) Unplanned, unexpected, or inadvertent release, launch, or loss of any nuclear training device, or nonnuclear store on any nuclear capable station of a nuclear capable combat delivery vehicle.
- (4) Actual or suspected loss or compromise of codes, code materials, software, or equipment designated as critical components according to AFR 12-4.
- (5) Damage, malfunction, or failure of nuclear capable combat delivery vehicles suspension, release, launch, separation, arming, monitoring and control system.
- (6) Nuclear certified ground support equipment including common commercial vehicles and munitions handling equipment (10:81).

Enhanced Fire Control Computer (EFCC). The EFCC works with the ACIU to act as central computers, coordinates sensors, displays and modes and provides system level processes such as air-to-ground bombing solutions that require inputs from several sources (18:3-2).

Exhibit. The failed/deficient or nonconforming item (15:1-2).

Fail-Safe. A design feature of a nuclear weapon system or component which insures that a critical function or personnel injury will not occur because of a failure in the system or component (12:29).

Firmware. Software that resides in a nonvolatile medium which is read-only in nature. Firmware is completely write-protected when functioning in its operational mode (12:29).

Hardwire. A dedicated discrete electrical circuit (12:29).

Jettison/Release Remote Interface Unit (J/R RIU). Portion of SMS that generates signals for the jettison of air-to-ground weapons.

Line Replaceable Units (LRU). Those components that can be removed and replaced at the unit level of maintenance. For example, LRUs such as the NRIU can be removed and replaced by munitions loaders while working on an aircraft on the flightline.

Maintenance Fault Listing (MFL). A listing of system faults that were discovered by tests built into the aircraft's avionics system, either inflight or on the ground (18:10-1 through 10-5).

Materiel Deficiency Report (MDR). A report of a product deficiency (15:1-3).

Materiel Improvement Project (MIP). A MIP is a planned effort to investigate and resolve deficiencies or to evaluate proposed enhancements. A MIP is established whenever a deficiency or enhancement is determined to warrant further investigation or consideration and is used to monitor and control all actions related to it (15:1-3).

Multiplexed System. A signal transmission system in which two or more signals share one transmission path or bus (12:29).

Normal Environment. The expected logistical and operational environments which the weapon or combat delivery vehicle is required to survive without degradation in operational reliability (12:29).

Nuclear Consent Function. A function implemented by a deliberate act that provides two-person control over the release system unlock and nuclear weapon prearm functions (12:29).

Nuclear Mode. Situation or event occurring when the aircraft is configured to release or simulate the release of nuclear weapons (23).

Nuclear Safety Criteria. Design and evaluation criteria set as guides for ensuring that nuclear safety is a basic system engineering and procedural requirement in nuclear weapon and logistic systems (12:30).

Nuclear Surety. A term used to encompass all activities that ensure Air Force compliance with the four DOD Nuclear Weapon System Safety Standards. To comply with these standards, Air Force nuclear weapon systems must be designed, maintained, transported, stored, and employed to incorporate maximum safety consistent with operational requirements (14:1-2).

Nuclear Surety Officer (NSO). Normally a full-time individual who manages a base, wing or equivalent nuclear surety program.

Nuclear Remote Interface Unit (NRIU). SMS component that conditions and releases nuclear weapons (18:3-15).

Nuclear Weapon. A device in which the explosion results from the energy released by reactions involving atomic nuclear fission or fusion or both (14:3).

Nuclear Weapon System. A combat delivery vehicle with its nuclear weapon or weapons and associated support equipment, noncombat delivery vehicles, facilities, and services (14:3).

Nuclear Weapon System Safety Rules. Secretary of Defense-approved procedural safeguards governing all operations with nuclear weapons or nuclear weapon systems. The safety rules establish procedures to ensure compliance with the four Nuclear Weapon System Safety Standards in DOD Directive (3150.2) (14:3). The Nuclear Weapon System Safety Rules for the F-16 are contained in AFR 122-26 (13:1).

Nuclflash. An accidental, unauthorized, or any other unexplained incident which involves launching, firing, or use by U.S. forces or U.S.-supported allied forces, of a nuclear-capable weapon(s) system which could create the risk of outbreak of war, including:

(1) Detonation of a nuclear weapon.

(2) Launch of a nuclear-armed or nuclear-capable missile.

(3) Unauthorized flight or unauthorized deviation from an approved flight plan by a nuclear-armed or nuclear-capable aircraft with the capability to penetrate the airspace of the USSR or other Warsaw Pact countries.

Originating Point. Activity within a component (Army, Navy, Marines, Air Force, Coast Guard, DLA or GSA) which discovers a product deficiency and reports it (15:1-3).

Prearmed. The state of a weapon system in which launch or release of the weapon will start the sequence necessary to produce a nuclear detonation (12:30).

Screening Point. An office within the originating activity which reviews reports to assure they are valid, com- plete, accurate, and properly addressed; assigns report control numbers (RCNs); ensures proper marking and handling of exhibits; transmits reports to the contact point activity; monitors outstanding reports; and acts as the focal point for communications with the contact/ action point (as appli- cable) (15:1-3 through 1-4).

Software. A series of instructions or statements (including firmware) designed to cause an electronic computer (automation) to execute an operation (12:30).

Stray Voltage. An unintended voltage existing in any part of a weapon system (12:31).

Support Point. The activity that assists the action point (as requested) in processing, investigating, and resolving a deficiency. Examples are: Contract Administration Office, engineering support offices, other ALCs, etc. This activity may or may not be colocated within the action point activity (15:1-4).

Service Replacement Unit (SRU). Subcomponents of LRUs that can be repaired at an intermediate level maintenance shop. For example, circuit cards in an NRIU can be removed/repaired at an Avionics Intermediate Shop.

[redacted]

Warranty Manager. The individual, normally within AFLC or AFSC, responsible for warranty administration (15:1-4).

Work Unit Code. An alpha-numeric code consisting of five characters. It identifies the system, the subsystem, and the component that was worked on (16:11-001).

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Vita

Captain William J. Hammer was born on 23 October 1957 in Buffalo New York. He graduated from high school in Hamburg, New York in 1975 and attended Erie Community College and The State University College at Buffalo from which he received a Bachelor of Science Degree in Criminal Justice in May 1979. Upon his completion of Officer's Training School, he was commissioned in the U. S. Air Force in February 1981. He then attended Munitions Officer training at Lowry AFB, CO. His first assignment was as the Officer in Charge of Reentry Vehicle Maintenance at Whiteman AFB, MO. His second assignment was at the 50th Ammunition Supply Squadron, Wenigerath GE, where he served as the Munitions Storage and Handling Branch Chief and as the Maintenance Supervisor. His third assignment was at Hahn AFB GE, where he served as the Weapons Safety/Nuclear Surety Officer. While at Hahn, he received the USAF Chief of Staff Individual Safety Award and The USAF Inspector General Nuclear Surety Special Achievement Award. He entered the School of Systems and Logistics, Air Force Institute of Technology in May 1987.

Permanent address: [redacted]

The purpose of this research was to determine what problems existed for reporting Dull Swords on the F-16 and what improvements could be made to the cumbersome investigation and reporting process. The complexity of the F-16's multiplexed arming, monitoring and control system (MUX AMAC) was determined to be the major problem source. Personnel involved in the reporting process were uncertain of what failures to report as Dull Swords, because most of the MUX AMAC circuitry and components were used to deliver conventional weapons (i.e. missiles and bombs) and nuclear weapons. Safety personnel interviewed desired more detailed reporting guidance on this dilemma.

MUX AMAC experts were interviewed to determine what types of failures needed to be reported and what type of information is needed in the reports. This information was used to develop better reporting guidance for units to follow.

The guidance developed was then used in conjunction with two computer products: a maintenance history report on each of the major MUX AMAC components obtained from the Central Data System (CDS), and a Dull Sword summary report obtained from the Directorate of Nuclear Surety's AID Data File to determine whether units had been reporting a representative number of Dull Swords. The analysis found that over 50 percent of the Nuclear Remote Interface Units failures were not reported, as well as several Dull Swords on other components. The author suggested that many other Dull Swords may have occurred, but this could not be confirmed due to superficial information being entered into the CDS.

The author analyzed the possibility of using the CDS or similar systems to replace or improve the current reporting system. The research found that the investigation/reporting process at units could be streamlined if more detailed information was entered into the systems. Several recommendations for improvement were given.

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