RAS 5419 72-22-ISFSI — Applicant Exhibit 198 - Rec'd 7/1/02

SUMMARY OF FACTS

ENGINE FAILURE
F-16CG ACCIDENT
8 JAN 98

AFI 51-503
REPORT OF AIRCRAFT ACCIDENT INVESTIGATION

1. **AUTHORITY:** Under the provisions of Air Force Instruction (AFI) 51-503, *Aircraft, Missile, Nuclear, and Space Accident Investigations*, on 9 February 1998, the Twelfth Air Force Commander, Lieutenant General Lansford E. Trapp, appointed Lieutenant Colonel Jeffrey S. Tice to conduct an aircraft accident investigation after F-16C, aircraft number 89-2131, crashed near Wendover, Utah (*Tab Y-2*). No damage was caused to private property (*Tab P-2*). The investigation was conducted at Hill Air Force Base, UT from 9 February 1998 through 27 February 1998. The technical advisors were Major Daryl L. Bell (legal), Capt Anthony S. Dee (medical), 1Lt Fausto A. Padilla (maintenance) and Mr. Jeffrey G. Catron (propulsion) (*Tabs Y-3 thru 5*).

2. **PURPOSE:** An aircraft accident investigation is convened under AFI 51-503. The investigation is intended primarily to gather and preserve evidence for claims, litigation, disciplinary and adverse administrative actions, and for all purposes other than mishap prevention. In addition to setting forth factual information concerning the accident, the board president is also required to state his opinion concerning the accident (if there is clear and convincing evidence to support that opinion), or to describe those factors, if any, that in the opinion of the board president substantially contributed to the accident. This investigation is separate and apart from the safety investigation conducted under AFI 91-204, *Safety Investigations and Reports*. The report is available for public dissemination under the Freedom of Information Act (5 U.S.C. 552) and AFI 37-131, *Freedom of Information Act Program*. Accident board members were convened to investigate the Class A aircraft accident, F-16C, S/N 89-2131, from the 388th Fighter Wing, Hill AFB, UT, which occurred on 8 January 98 at 1651 local (L) hours / 2351 zulu (Z) hours. The accident occurred approximately 16 miles northeast of Wendover, Utah. There were no casualties (*Tab A-2*). The extent of property loss was $27,416,810 (*Tab M-2*).

3. **SUMMARY OF FACTS:**

a. **History of Flight Activity:** The Mishap Pilot (MP), Lt Col Judson R. Kelley, began briefing for the flight at approximately 1400L. The MP was number two of a four ship flight of F-16CG aircraft and was assigned the call sign of Colt 2 (*Tab K-2*). During the mishap pilot's briefing, the weather was forecast to be clear (20 miles visibility) with some high clouds (25,000-29,000 feet) and the winds were forecast to be light (*Tab W-3*). Sunset was at 1716L (*Tab W-3*). The mishap flight took off from Hill AFB on 8 Jan 98 at 1616L

PFS Exh. 198
58695

Template = SECY-028

SECY-02

NUCLEAR REGULATORY COMMISSION

Docket No. _____ Exh No. 198

In the matter of PFS

Staff ✓

Applicant ✓

Intervenor _____

Contention _____ Date 7/1/02

Other _____ Witness _____

Reporter EB

with the call signs of Colt 1 through 4 (*Tab K-2*). The flight proceeded west of Hill AFB, rejoined to box formation and entered the Lucin B Military Operating Area (MOA) descending to low altitude. The flight continued their planned low altitude routing to just north of the Lucin VORTAC navigational aid, turned south and entered the Craner's Range area to begin simulated weapons deliveries (*Tab V-2*). At approximately 1648L, during the third simulated attack of the day, surface attack tactics sortie, the number two aircraft experienced an engine compressor stall and brief fire (*Tab N-2*). The MP began an immediate climb, accomplished the critical action procedures for a low altitude engine failure, and attempted two airstarts (*Tab V-1*). The MP turned the aircraft to the nearest suitable runway at Wendover, Utah to setup for a flameout landing (*Tab N-2*). The airstarts were unsuccessful and the MP noted the engine RPM (revolutions per minute) dropped to zero indicating a complete engine seizure (*Tabs V-1, N-2*). The mishap pilot noted his flight conditions (airspeed, altitude, and distance to the nearest runway) would not allow him to glide to the runway at Wendover (*Tab V-1*). He then accomplished pre-ejection procedures and initiated a successful ejection at approximately 1650L (*Tab N-2*). The MP ejected from the aircraft without injury (*Tab A-2*). The mishap aircraft impacted on federal land in the Utah Test and Training Range (UTTR) 15.5 nautical miles (NM) northeast of Wendover, Utah and was completely destroyed (*Tabs A-2, R-2*). The 388th Fighter Wing Public Affairs Office at Hill AFB, UT handled questions about the mishap and responded to numerous local media inquiries in the days immediately following the accident. On the day of the accident, *CBS Evening News* requested information on the safety stand-down of flying operations to air on 9 January 1998 (*Tab EE-2*). In addition, KUTV (CBS), KTVX (ABC), KSLTV (NBC), KSTU (FOX) all covered the accident in their local news broadcasts. News print coverage consisted of the *Ogden Standard Examiner*, *Deseret News*, and the *Salt Lake Tribune*. KSL and KENZ Radio also covered the accident (*Tab EE-2*). Due to the fact that the mishap occurred on federal land and there was no personal property damage or injury, the media's interest was short-lived.

b. **Mission:** The purpose of the mission was to fly a surface attack tactics (SAT) mission practicing weapons delivery parameters using multi-ship tactics (*Tab V-2.1*). The route was typical of normal sorties flown in the Utah Test and Training Range (UTTR) complex when performing simulated attacks on Craner's Range from low altitude. The majority of the mission was to be flown in daylight, with landing scheduled after official sunset (*Tab K-2*).

c. **Briefing and Preflight:** Capt Kevin J. Jens using locally generated briefing guides conducted the mission briefing. The briefing procedures were typical of a day, surface attack tactics briefing for a four ship of F-16C pilots. All pilots interviewed stated there were no problems or misunderstandings during the briefing (*Tabs V-1 thru V-3*). The mishap pilot's crew rest was within established regulations (*Tab X-5*). The MP's preflight of the mishap aircraft was unremarkable (*Tab V-1*).

d. **Flight Activity:** The flight plan was in the standard format, outlining the mission's route of flight. All turn points and targets were well marked and defined. Nothing was noted out of

the ordinary (*Tabs V-1 thru V-3*). All communications between the mishap pilot and control agencies were clear and understandable (*Tabs N-2 thru N-6*). No navigational difficulties were noted (*Tabs V-1 thru V-3*).

(1) The mishap flight took off from Hill AFB on 8 Jan 98 at 1616L with the call signs of Colt 1 through 4 (*Tab K-2*). The flight proceeded west of Hill AFB, rejoined to box formation, and descended to low altitude upon entering the Lucin B Military Operating Area (MOA). The flight continued westbound on their planned low altitude routing just north of the Lucin VORTAC navigational aid, then turned south and entered the Craner's Range area to begin simulated weapons deliveries (*Tab V-2.2*).

(2) The mishap flight entered the range working area in box formation with the two elements separated by 3-4 miles. The first two attacks were planned with a low altitude ingress eastbound from Floating Island (a landmark hill 20 NM northeast of Wendover, UT (*Tab R-2*)) to element pop-ups executing a 10 degree dive for the flight lead (Colt 1) and a 20 degree dive for the rest of the flight (Colt 2, 3, and 4) (*Tab V-2.2*). The post-attack egress was a counter-clockwise flow to the North and West of the target then proceeded southeast around Grand Peak to align the flight for subsequent attacks. The first two attacks went as briefed. The third attack was planned as a 30 degree climb to high altitude then executing a 45 degree dive, high altitude bomb release (*Tab V-2.2*).

(3) As Colt 1 and 2 cleared the south end of Grand Peak, the mishap flight lead called for an in-place 90-degree left turn to point at the target area (*Tab 1.2*). As the MP rolled out of this turn, he noted he was slightly aft of briefed formation position (line abreast) and, due to fuel considerations, elected not to use afterburner to regain position. The MP confirmed his throttle at military power (full throttle short of afterburner), decreased the g loading on the aircraft to accelerate and began moving forward into position for the attack. At approximately 1648L descending through 1000 feet above ground level (AGL) and in excess of 500 knots airspeed, the MP heard a "big bang" and experienced an immediate loss of thrust (*Tab V-1.2*). The MP immediately initiated a climb, called "knock it off," and began analyzing engine instruments. He noted the Fan Turbine Inlet Temperature (FTIT) passing 1100 degrees and engine RPM rapidly rolling back. The MP continued critical action procedures (CAPs) for low altitude engine failure, by jettisoning the external tanks, placing the throttle off, then back on, attempting an airstart (*Tab V-1.3*). The mishap flight lead acknowledged the knock it off and informed the MP there were "...flames coming out your back" (*Tab N-2*). The MP noted the FTIT exceeding normal operating limits again and retarded the throttle to off a second time preparing for a second airstart. The MP placed the throttle back to midrange and noted the RPM "...frozen at zero" (*Tabs V-1.3, O-34*). During the climb the mishap aircraft reached an altitude of approximately 10,000 feet above mean sea level (MSL) or 5800 feet AGL and slowed to 220 knots airspeed. (*Tab O-30*).

(4) Once at altitude, the MP initiated a 15-20 degree banked right turn to the South attempting to glide the mishap aircraft to Wendover airfield approximately 20 miles southwest of his position. The mishap pilot noted his flight conditions (airspeed, altitude, seized engine, and distance to a suitable runway) would not allow him to glide to Wendover (*Tab V-1.3*). He made the decision to eject, accomplished pre-ejection procedures, and initiated a successful ejection at approximately 1650L (*Tab N-2*). After ejection, the mishap aircraft continued in a shallow descent on a southerly heading for approximately 17 seconds until impact (*Tab O-36*).

e. **Impact:** The aircraft impacted near geographic coordinates N 40.47 W 113.46; approximately 15.5 miles northeast of Wendover, Utah on 8 January 98 at 1651L hours (*Tab A-2*). The aircraft impacted in a muddy area at between 190 and 200 knots airspeed in a wings level, 15 degrees nose low attitude with 5.5-7.5 degrees angle of attack (AOA) (*Tabs O-30, 31*). The engine was not rotating at impact (*Tabs V-5.7, O-34*).

f. **Egress System:** All egress system inspections were current (*Tab CC-15*). The pilot initiated a successful ejection well within the performance envelope of the Advanced Concept Ejection System (ACES II) ejection seat, approximately 1700 feet above ground level (AGL) (*Tabs A-2, J-10*). Post-crash investigation revealed all egress systems functioned as designed during the ejection episode (*Tab J-14*). However, the ejection handle cable broke at the point where it exits through the handle stowage detent. This breakage was a result of the MP holding on to the handle at the time of seat-man separation. This breakage is not considered a system or material failure (*Tab J-12*).

g. **Personal and Survival Equipment:** Personal and Survival equipment inspections were current (*Tabs CC-17 thru 24*). The MP's survival radio functioned normally (*Tab N-4*). However, the emergency locator transmitter (ELT) beacon activated but operated intermittently for approximately 16 seconds then quit completely (*Tab I-2*). Post-crash analysis of the malfunctioning ELT determined the ambient temperature of the battery was below the operating range of the battery for it to transfer its stored energy to power up the beacon (*Tab J-15*). The malfunctioning ELT did not contribute to any rescue problems. The mishap flight lead was able to watch the MP descend in the parachute and quickly pass his position to the rescue team (*Tab V-2.4*).

h. **Rescue:** The MP ejected at 1650:51L and the mishap aircraft impacted the ground at 1651:08L. Colt 3 notified Wendover Tower of the ejection and crash, then requested local authorities send out a helicopter. In addition, he instructed the local fire and rescue to start travelling east on Interstate Route-80 (I-80) toward the crash site at 1651:12L (*Tab N-3*). At the same time Colt 1 notified Clover Range Control (*Tab N-3*). Tooele County Fire and Rescue ground mobile unit traveled 17 miles east on I-80. However, the rescue team was unable to drive directly to the crash site due to muddy, uneven terrain. Two paramedics continued on foot and reached the mishap pilot at approximately 1840L (*Tab V-1.5*). Ten

minutes later, an Army rescue helicopter dispatched to the crash site arrived and took the pilot back to Hill Air Force Base (*Tab EE-18*).

i. **Crash Response:** Immediately following Colt 1's acknowledgment of Colt 2 having an engine fire (1648:47L), Colt 1 notified Clover Range Control and Colt 3 notified Wendover Tower of Colt 2's emergency and flight path change to Wendover (*Tabs N-1 thru 4*). The MP ejected at 1650:51L and the mishap aircraft impacted the ground at 1651:08L. Following the impact, Colt 1 and Colt 3 coordinated the Search and Rescue (SAR) effort (*Tab V-3.2*). Tooele County Fire and Rescue Mobile Ground Unit responded via coordination through Wendover Tower and Colt 3. At 1654:07L, the mishap pilot notified Colt 1 he appeared to be uninjured (*Tab N-4*). At 1655L Colt 1 notified Command Post (*Tab EE-18*). The Fire and Rescue crew were unable to reach the MP by vehicle due to the muddy flats between Interstate 80 and the mishap site. Two paramedics proceeded on foot and reached the MP at 1840L. Ten minutes later, an Army rescue helicopter arrived on scene and transported the pilot back to Hill AFB arriving at 1920L (*Tab EE-18*). The MP was transferred from the flightline via ambulance to the Hill AFB hospital and post-mishap physical examination revealed no significant trauma/injury (*Tab X-3*). The weather was clear and had no bearing on the rescue efforts with the exception of muddy terrain and impending darkness (*Tab W-3*). At 2245L the Mobile Command Post was established and running. At 0010L on 09 January 1998, UTTR security forces were briefed and in place to secure the crash site. No civilians or local law enforcement were present at crash site (*Tab EE-14*).

j. **Maintenance Documentation:** A review of the active maintenance forms for the mishap aircraft (MA) noted no discrepancies and no evidence to indicate any pending mechanical, or electrical failure (*Tab H-2*). A review of the previous 30 days of the Core Automated Maintenance System (CAMS) and the mishap aircraft historical files divulged no negative trends, open discrepancies in flightline maintenance actions, scheduled inspections, nor time change items contributing to this accident (*Tab H-2*). A thorough review of the MA's Automated Records Check (ARC) and Planning Requirements Automated (PRA) further indicated that all inspection and time change technical orders (TCTO's) were completed. The Maintenance technical advisor found no flightline maintenance procedure, practice, or performance to be related to the accident. However, wreckage analysis and a thorough review of the mishap engine's (ME) maintenance records indicated that the 388th Maintenance Squadron, Jet Engine Intermediate Maintenance (JEIM) shop skipped vital steps during a major engine overhaul (*See paragraph 3 m(5) herein, Tabs V-5.7, Z-3, U-57, 58*).

(1) The last major maintenance performed on the ME occurred between 6 March 1996 and 23 Sep 1996 in the 388th Maintenance Squadron, Jet Engine Intermediate Maintenance (JEIM) shop and passed the engine test cell run on 24 September 1996 (*Tabs H-6, U-50*). This maintenance action was a 6000 Total Accumulated Cycles (TACS) engine rebuild. This rebuild replaces nearly all the rotating components and many of the stationary ones including: the compressor, compressor stator cases, rear stator cases, combustion diffuser

nozzle (CDN), combustion chamber, high pressure turbine (HPT) shroud, HPT rotor, HPT nozzle, low pressure turbine (LPT), first stage nozzle, second stage nozzle, turbine frame, augmentor, exhaust nozzle, fan rotor, fan stator cases, number 3 bearing, number 2 bearing, main engine control, and other parts deemed unserviceable after inspection. (*Tabs H-6, CC-12*).

(2) During the period 17 June through 29 July 1996, all steps in procedure 9 of TO 2J-F110-6-11, work package 34 (*Tab BB-49*), were not accomplished during the build-up of the combustion diffuser nozzle (CDN) case (*Tabs U-57,58*). Work crews failed to install the combustor diffuser pressure (CDP) seal, and completed the engine re-assembly without the seal installed (*See paragraph 3 m(5) herein, Tabs Z-3, V-5.7*).

k. **Maintenance Personnel and Supervision:** The Maintenance technical advisor reviewed the AF Forms 623 (*On-The-Job Training Records*) and AF Forms 797 (*Job Qualification Standard Continuation/Command JQS*) of the crew chiefs, specialists, weapons, egress and engine repair personnel. The individuals assigned to work the mishap aircraft were properly trained and held the required skill level for performing the assigned duties. He also determined that the 34th Fighter Squadron (FS) maintenance leadership provided adequate supervision and was effectively organized in the manner specified in Air Combat Command Instruction (ACCI) 21-166, *Objective Wing Aircraft Maintenance.* No flightline maintenance practice or procedure was deemed to be a factor in the accident. However, analysis of the ME's 6000 TAC inspection work package indicated the JEIM back shop crew chiefs, who annotated work completed between 17 June 1996 and 29 July 1996, failed to properly communicate and document the exact step where maintenance stopped during the engine re-assembly (*Tabs U-57, 58*). As a result, all steps in procedure 9 of TO 2J-F110-6-11, work package 34 (*Tab BB-49*), were not accomplished (*See paragraph 3 m(5) herein, Tabs Z-3, V-5.7*). All JEIM crew chiefs interviewed stated they could not recall specifics about the re-assembly due to the extended period of time (nearly 18 months) that had elapsed between the maintenance actions and the mishap (*Tabs V-4.19, V-6.6, V-7.6, V-8.2*).

l. **Engine, Fuel, Hydraulic, and Oil Inspection Analysis:** The Maintenance technical advisor and Engine specialist reviewed all engine data, including Comprehensive Engine Management System (CEMS) (*Tabs H-5 thru H-7*). Review of the ME's 6 year history revealed the mishap engine had experienced problems; to include high oil consumption and high amounts of copper/iron readings in the oil samples (*Tabs H-5 thru H-7*). Post impact oil samples taken from the turbine frame scavenge pump indicated extremely high levels of iron (*Tab AA-2*). These high iron readings and the metal shavings found on the oil system master chip detector (MCD) are attributed to bearing failure (*Tabs CC-4, J-2, S-5*). However, review of oil samples taken from the ME between 1 December 1997 and 7 January 1998 showed no negative trends or indications of impending catastrophic engine failure (*Tabs H-5, AA-5*). After the 6000 TAC rebuild, the engine flew 178.3 flight hours and accumulated 563 TACS prior to the mishap (*Tabs H-5, 6*) with no indications of impending bearing failure.

m. Airframe and Aircraft, Missile, or Space Vehicle Systems:

(1) The MP did not indicate any problems in the avionics, mechanical, electrical or hydraulic systems throughout the mission (*Tab V-1*). The pilot of Colt 3 indicated he flew the mishap aircraft on 7 January 98 and noted no "...anomalies, weaknesses, or any strange performance. It was a normal performing airplane" (*Tab V-3.4*).

(2) Analysis of the CSFDR (Crash Survivable Flight Data Recorder) data revealed that approximately 32 minutes into the flight, engine core speed began to decay at a very fast rate (*Tab O-34*). From that moment in time the ME's core and fan shafts no longer responded to throttle inputs from the cockpit. Core and fan speeds decayed to sub-idle speeds within a matter of seconds and two airstarts were attempted but they did not result in either fan or core speed increases (*Tab O-37*).

(3) Engine wreckage analysis of the ME fan section revealed positions corresponding to very low speed or zero speed operation at impact (*Tabs J-3, J-4, V-5.7*). Both the rotor and stator components of the fan section showed no evidence of pre-impact foreign object damage (FOD) (*Tab J-3*).

(4) Analysis of the ME compressor section revealed the number 3 (thrust) bearing was severely damaged. Molten metal was observed between the bearing races and balls, and between the balls and the cage supporting the bearing (*Tabs J-3, S-6*). All of the ball bearings were present, though frozen in place, due to severe smearing and metal flow on surfaces facing the ball track of the forward inner race (*Tab J-3*). The inner race had shifted approximately 0.08 inches aft relative to the outer race (*Tab J-3*). The compressor rotor section was missing the entire airfoil sections of the 7^{th}, 8^{th}, and 9^{th} stage rotor blades (*Tab S-7*). Machining rub between the trailing edges of the compressor blade platforms and vane inner band seal segments indicates the HPT rotor shifted aft during operation (*Tab J-4*).

(5) Inspection of the combustor diffuser nozzle (CDN) case revealed that the combustor discharge pressure (CDP) honeycomb stationary seal was not installed on the CDN case (*Tabs V-5.7, J-4, Z-3*). This seal's primary purpose is to decrease the axial pressure loading on the high-pressure turbine (HPT) shaft (*Tab CC-3*). Analysis performed by GE engineers estimated that the HPT shaft axial loading increases from 8,394 lb. with the CDP seal present to 30,721 lb. without the CDP seal (*Tab CC-7*). The #3 bearing is the only bearing capable of supporting axial loads on the HPT shaft, its loading increases proportionally without the presence of the CDP seal (*Tab CC-3*). The #2 bearing, which is physically located inside the same sump as the #3 bearing, showed few signs of distress and had a light coating of oil (*Tab J-3*). The primary and auxiliary oil jets to the bearings were not blocked (*Tab J-3*). Chips found on the master chip detector indicate oil was being supplied to the bearing at the time of failure (*Tabs J-2, S-5, CC-4*). Bearing lubrication was not the cause of the bearing failure. Normally, most #3 bearing

failures are caught prior to catastrophic failure by post-flight chip detector inspections (*Tab CC-14*). However, review of oil samples taken from the ME between 1 December 1997 and 7 January 1998 showed no indications of impending catastrophic bearing failure (*Tabs H-5, AA-5*)

n. **Operations Personnel and Supervision:** Lt Col Jeffrey Harrell properly authorized the mission (*Tab K-2*). Pilot interviews confirm the briefing thoroughly covered all aspects of the flight (*Tabs V-1 thru V-3*). Nothing was noted that contributed to the mishap.

o. **Pilot Qualifications:** A thorough review of the mishap pilot's Flight Evaluation Folder and F-16C grade book noted nothing that could have contributed to the mishap (*Tabs T-2 thru T-5*). The mishap pilot is a highly experienced fighter pilot with 2,184.3 total flying hours. He has 696.3 flying hours in the F-16 aircraft, including 48.5 hours of combat experience. Recent flight time is as follows (*Tab G-2*):

Period	Hours	Sorties
30 days	2.0	2
60 days	34.5	11
90 days	54.9	19

p. **Medical:** A thorough review of the mishap pilot's medical record demonstrated the pilot to be medically qualified in performing all flying duties (*Tab X-9*). Crew rest parameters were appropriately adhered to and the MP was relaxed without any significant stressors affecting his ability to carry out the mission (*Tab X-5*). He was without any illness, sleep deprivation, or on any medications at the time of the incident (*Tab X-3*). Toxicology specimens contained no alcohol, elevated carbon monoxide, or illegal substances (*Tab X-8*).

q. **Navaids and Facilities:** Navigational aids (Navaids), facilities and notices to airmen (NOTAMs) were reviewed. Nothing was noted that could have contributed to the mishap.

r. **Weather:** Surface weather observations and satellite imagery for the North Range (this includes the Craner's Range complex) valid at 2300Z/1600L on the date of the incident indicated clear skies, unrestricted visibility. (*Tabs W-2, 3*) Winds at 5000 feet were 10 knots from 270°. The temperature at 5000 feet was -01°C with an altimeter setting of 29.84 (*Tab W-3*). Nothing was noted that could have contributed to the mishap.

s. **Governing Directives and Publications:** Primary instructions and technical orders (T.O.) relevant to this investigation are:

T.O. 1F-16CG-1
T.O. 2J-F110-6-4
T.O. 2J-F110-6-11

There is at least one known deviation from technical order publications. The 388th Maintenance Squadron, Jet Engine Intermediate Maintenance (JEIM) shop skipped vital steps during the build up of the combustion diffuser nozzle (CDN) case. All steps in procedure 9 of TO 2J-F110-6-11, work package 34, were not accomplished (*Tab BB-49*). Work crews failed to install the combustor diffuser pressure (CDP) seal (*Tabs V-5.7, S-7*).

Date: 27 FEB 98

JEFFREY S. TICE
Lt Col, USAF
Board President

STATEMENT OF OPINION

ENGINE FAILURE
F-16C, S/N 89-2131 ACCIDENT

8 JANUARY 98

1. UNDER 10 U.S.C. 2254(d) ANY OPINION OF THE ACCIDENT INVESTIGATORS AS TO THE CAUSE OR CAUSES OF, OR THE FACTORS CONTRIBUTING TO, THE ACCIDENT SET FORTH IN THE ACCIDENT INVESTIGATION REPORT MAY NOT BE CONSIDERED AS EVIDENCE IN ANY CIVIL OR CRIMINAL PROCEEDING ARISING FROM AN AIRCRAFT ACCIDENT, NOR MAY SUCH INFORMATION BE CONSIDERED AN ADMISSION OF LIABILITY OF THE UNITED STATES OR BY ANY PERSON REFERRED TO IN THOSE CONCLUSIONS OR STATEMENTS.

2. The primary cause of this mishap, supported by clear and convincing evidence, was failure to follow technical order (T.O.) guidance during a major engine repair. The 388th Maintenance Squadron, Jet Engine Intermediate Maintenance (JEIM) shop, during a 6000 total accumulated cycles (TACS) inspection and repair of the F110-GE-100 engine, serial number 510519, did not accomplish all steps in procedure 9, work package 34 of T.O. 2J-F110-6-11. Between 6 March 1996 and 23 September 1996, JEIM work crews failed to install the stationary combustor diffuser pressure (CDP) seal, and completed the engine rebuild without the seal. The CDP seal's primary purpose is to decrease axial pressure loading on the high-pressure turbine (HPT) shaft. Without this seal, the axial loading on the number 3 bearing supporting the HPT shaft increased from 8,394 lbs. to 30,721 lbs. The four-fold increase in operating stress caused the number 3 bearing inner race to wear down allowing .080 inches of movement. This excess movement allowed the entire HPT shaft to shift aft and rotating components struck stationary ones causing severe airflow disruption and an engine compressor stall. This compressor stall forced the HPT shaft to shift forward placing abnormally high loads against the number 3 bearing. Following the engine stall, the rapidly shifting, abnormally high axial load caused the number 3 bearing to immediately overheat and catastrophically fail. This catastrophic bearing failure caused the HPT rotor to seize and prevented any possible airstart.

3. Poor communication and sketchy documentation practices allowed work crews to complete the engine rebuild without the CDP seal. The engine rebuild took nearly seven months from beginning to end because of parts availability, deployment commitments and manpower limitations (*Tab V-4.5*). Specifically, a six-week period elapsed between beginning the compressor diffuser nozzle (CDN) assembly and installation of the CDN to the engine core (*Tabs V-4.23, U-57, 58*). While this length of delay is not uncommon, the 388th JEIM shop daily maintenance logs were the only record available to work crews to determine what rebuild steps had been completed between work delays on any given engine. The JEIM shop crew supervisors, who annotated work done in the mishap engine's daily maintenance log, failed to

properly communicate the exact work completed during the re-assembly. The individual or crew who installed the CDN assembly to the engine core improperly assumed the CDN assembly was complete and ready for installation to the core. Once the CDN assembly is installed to the core, it is extremely difficult to check the CDP seal location (*Tabs V-6.7, V-7.10*). At the time of the engine rebuild, neither the T.O. or local maintenance practices called for a supervisory inspection of the completed CDN assembly before installation to the engine core (*Tab V-5.10*). The accident board was unable to determine which crew or individual was responsible failing to install the CDP seal. In my opinion, if the annotations in the written maintenance log had included the precise T.O. steps completed the CDP seal would have been correctly installed.

4. The mishap pilot accurately determined the engine had seized and would not restart. He correctly analyzed his flight parameters, determined he could not accomplish a flameout landing at the nearest suitable airfield, and elected to eject (*Tab V-1*).

Date: 27 FEB 98

JEFFREY S. TICE
Lt Col, USAF
Board President