EXECUTIVE SUMMARY

AIRCRAFT ACCIDENT INVESTIGATION, F/A-22 S/N 00-4014

422nd TEST AND EVALUATION SQUADRON
NELLIS AIR FORCE BASE (AFB), NEVADA
20 DECEMBER 2004

On 20 December 2004, at 2340Z/1540 local time, the Mishap Aircraft (MA), F/A-22, Serial Number 00-4014, crashed on initial takeoff from Nellis AFB. The Mishap Pilot (MP), assigned to the 422nd Test and Evaluation Squadron, Nellis AFB, ejected safely and sustained only minor injuries. There were no other casualties. The MA impacted the Nellis AFB airfield and was destroyed. The only other damage was also to government property including an arresting cable, a runway sign, a runway light, and the runway surface.

Immediately upon leaving the ground, the MA began a series of un-commanded and progressively more violent yaw, roll, and pitch transients. Unable to control the aircraft, the MP ejected seconds before the MA impacted the ground.

The Accident Investigation Board President determined the cause of the mishap, supported by clear and convincing evidence, was an inoperative Flight Control System, resulting from a power interruption, which made the MA uncontrollable. The MP was , unaware of this condition because he did not perform an Initiate Built in Test (IBIT), the only means of detecting the problem. Failure to perform the IBIT was the result of ambiguous Technical Orders and a mistaken belief in continuous RSA power availability.

During the mishap sequence, the MP started engines, performed an IBIT, and had a fully functioning Flight Control System. Subsequently, the MP shut down engines to allow maintenance personnel to service the Stored Energy System. During engine shut down, the MA's Auxiliary Power System (APU) was running. The MP believed the APU provided continuous power to the Flight Control System, and therefore another IBIT after engine restart was unnecessary. This belief was based on academic training, technical data system description, and was shared by most F/A-22 personnel interviewed during the investigation.

In fact, the MA's Flight Control System did experience a brief power interruption during the engine shut down sequence. The interruption produced an unforeseen catastrophic Flight Control System failure that rendered the MA un-flyable.

Under 10 U.S.C. 2254(d), any opinion of the accident investigators as to the cause 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 by the United States or by any person referred to in these conclusions or statements.

SUMMARY OF FACTS AND STATEMENT OF OPINION

F/A-22A ACCIDENT
20 December 2004

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COMMONLY USED ACRONYMS & ABBREVIATIONS

120's	Missiles
AC	Alternating Current
ACC	Air Combat Command
ACES II	Advanced Concept Ejection System (ejection seat)
ADS	Air Data System
AF	Air Force
AFB	Air Force Base
AFI	Air Force Instruction
AFPAM	Air Force Pamphlet
AFSC	Air Force Specialty Code
AFTO	Air Force Technical Order
AGL	Above Ground Level
AGM	Air-to-Ground Missile
AHC	Advanced Handling Characteristics
AIB	Accident Investigation Board
AMU	Aircraft Maintenance Unit
AMXS	Aircraft Maintenance Squadron
AOA	Angle of Attack
APG	Air Power Ground
APU	Auxiliary Power Unit
AR	Air Refueling
ARS	Air Recharge System
ATIS	Air Traffic Information System
AVA	Air Vehicle Acceptance
BAT OPS	422nd Operations
BFM/TX	Basic Fighter Maneuvers in Transition Phase
BITS	Built-in Tests
CAMS	Core Automated Maintenance System
CCDL	Cross Channel Data Link
CEDU	Comprehensive Engine Diagnostics Unit
CIPS	Common Integrated Processors
CR	Change Request
CSMU	Cockpit Survivable Memory Unit
CTK	Consolidated Tool Check
Dash-1	T.O. 1 F/A-22A-1
DCC	Dedicated Crew Chief
DET	Detachment
DTC	Data Transfer Cartridge
EED	Electro-Explosive Device
EESS	Emergency Escape Sequencing System
EMD	Engineering Manufacturing Development
EOR	End of Runway
EP	Emergency Procedures
ER	Exceptional Release
ERB	Engineering Review Board
FADEC	Full Authority Digital Electronic Controller
FDR	Flight Data Recorder
FLCS	Flight Control System
FOD	Foreign Object Damage
FRC	Fault Reporting Code
FTD	Field Training Detachment
GDC	Generator Distribution Center
GM	Global Management
IAW	In Accordance With
IBTT	Initiated Built-In Test
ICAW	Integrated Cautions and Warnings
IFPC	Integrated Flight/Propulsion Control
IMIS	Integrated Maintenance Information System
IPT	Integrated Process Team
KCAS	Knots Calibrated Airspeed
KEAS	Knots Equivalent Air Speed
Knots	Nautical Miles Per Hour
Kw	Kilowatt
L	Local Time
LMA	Lockheed-Martin Aero
MA	Mishap Aircraft
MAN AUX	Manual Auxiliary
MBIT	Maintenance Built-in Test
MIL	Military
MLD	Missile Launch Detection
MOCC	Maintenance Operations Control Center
MOS	Maintenance Operations Squadron
MP	Mishap Pilot
MSL	Mean Sea Level
NOTAMS	Notice to Airmen
NWS	Nose Wheel Steering
OBOGS	On-board Oxygen Generating System
OFP	Operational Flight Program
OJT	On The Job Training
OPSO	Operations Officer
PACAF	Pacific Air Forces
PAO	Polyalphaolefin
PBIT	Periodic Built-in Test
PDC	Power Distribution Center
PICC	Processor Interface Controller and Communications

PLF	Parachute Landing Fall
PMA	Portable Maintenance Aide
PMG	Permanent Magnet Generators
PSM	Power Supply Module
PTU	Pressure Transducer Unit
QC	Quality Check
RPM	Rotations Per Minute
RSA	Rate Sensor Assembly
RW	Radar Warning
SES	Stored Energy System
SIB	Safety Investigation Board
SII	Special Interest Item
S/N	Serial Number
SPO	System Program Office
TCTO	Time Compliance Technical Order
TEG	Test and Evaluation Group
TES	Test and Evaluation Squadron
TMM	Thermal Management Mode
TMS	Thermal Management System
T.O.	Technical Order
TOD	Technical Order Data
TOLD	Take-off and Landing Data
TX	Transition
USAF	United States Air Force
USAFE	United States Air Forces in Europe
UART	Universal Asynchronous Receiver Transmitter
UWARS	Universal Water Activated Release System
VDC	Video Transfer Data
VMS	Vehicle Management System
VSS	Vehicle System Simulator
VTC	Video Transfer Cartridge
X-ride	Extra Ride
YFP	Configuration Process Branch
Z	Zulu or Greenwich Meridian Time (GMT)

The above list was compiled from the Summary of Facts, the Statement of Opinion, the Index of Tabs, and witness testimony (Tab V).

SUMMARY OF FACTS

1. AUTHORITY, PURPOSE, AND CIRCUMSTANCES

a. Authority.

On 12 January 2005, Lieutenant General Bruce A. Wright, Commander Air Combat Command (ACC) appointed Colonel Ted Kresge to conduct an aircraft accident investigation of the 20 December 2004 crash of an F/A-22A aircraft, serial number 00-4014, on Nellis Air Force Base (AFB), Nevada. The investigation took place at Nellis Air Force Base, from 17 January 2005 through 3 February 2005. Technical advisors were Lieutenant Colonel Jeffrey P. Rude (Legal), Lieutenant Colonel Edward J. Sullivan (Maintenance), Major Michael T. Hoepfner (Pilot), Captain Christopher M. Meyer (Medical) (Tab Y-2).

b. Purpose.

This aircraft accident investigation was convened under Air Force Instruction (AFI) 51-503. The primary purpose is to gather and preserve evidence for claims, litigation, and disciplinary and administrative actions. In addition to setting forth factual information concerning the accident, the board president is also required to state his opinion as to the cause of the accident or the existence of factors, if any, that substantially contributed to the accident. This investigation is separate and apart from the safety investigation, which is conducted pursuant to AFI 91-204 for the purpose of mishap prevention. The report is available for public dissemination under the Freedom of Information Act (5 United States Code (U.S.C.) §552) and AFI 37-131.

c. Circumstances.

The accident board was convened to investigate the Class A accident involving an F/A-22A aircraft, S/N 00-4014, assigned to the 53rd Wing, 422nd Test and Evaluation Squadron (TES), Nellis AFB, Nevada, which crashed on 20 December 2004.

2. ACCIDENT SUMMARY

Aircraft F/A-22A, S/N 00-4014, crashed on initial takeoff 20 December 2004 at 2340:12Z/1540:12L (Tab B-3) and impacted the ground at 36 degrees and 14.79 minutes north and 115 degrees and 01.41 minutes west, Nellis AFB, Nevada (Tab C-3). The Mishap Pilot (MP), Major Robert A. Garland, is assigned to the 422nd TES, 53rd Wing. The pilot ejected safely and sustained only minor injuries. The aircraft was totally destroyed upon impact with the loss valued at $133,569,918.00 (Tab P-3). In addition to the loss of the aircraft, other government property that was damaged included a BAK-12 arresting cable, a runway guide sign, a runway light, and runway 03R. The mishap aircraft (MA) broke into several pieces leaving a debris field scattered over the departure end of runway 03R and the runway overrun and ground area beyond the departure end. There were no civilian casualties, or damage to private property. The mishap was reported in the local media at the time it occurred, but interest in the incident has been minimal since the story was first reported.

3. BACKGROUND

The 422nd TES, located at Nellis AFB, Nevada is composed of aircrew and support personnel supporting six different flights of fighter and helicopter aircraft: A-10, F-15C, F-15E, F-16C, F/A-22 and HH-60G. The 422 TES conducts operational tests for ACC on new hardware and upgrades to each of the six aircraft in a simulated combat environment. The 422 TES also develops and publishes new tactics for these aircraft. The results of these tests directly benefit aircrews in ACC, Pacific Air Forces (PACAF) and United States Air Forces in Europe (USAFE) by providing them with operationally proved hardware and software systems. Current tests include employment of the AGM-65H missile by the A-10, developing night vision goggle employment tactics for the F- 16C, helmet-mounted sight capability for the F-15C, new avionics software updates for the F- 15E, employment tactics and training for the F/A-22 and improved combat search and rescue tactics for the HH-60G. Detachment l, located at Holloman AFB, New Mexico, is responsible for conducting operational tests and tactics development for the F-117A Stealth fighter.

4. SEQUENCE OF EVENTS

a. Mission.

The MP was RAPTOR I leading a flight of three, RAPTOR 1&2 and COWBOY 2 (F-15C) on a transition (TX)-add ride for proficiency. Mission was authorized by the 422 TES (Tab K-3). The sortie would focus on defensive Basic Fighter Maneuvers (BFM). The MP was still in initial qualification training, and required one more ride for graduation. RAPTOR 2 was a qualified F/A-22 Instructor Pilot. COWBOY 2, piloted by an F-15 Instructor Pilot from the USAF Weapons School, was the bandit. Once in the airspace, RAPTOR 1 and 2 would alternate fighting the F-15 (Tab V-5.4).

b. Planning.

Mission planning/briefing was thorough and complete. All pertinent information was briefed and understood by all in the flight. Weather, Notices to Airmen, and Emergency Procedure (EP) of the day were briefed. Excellent detail was provided to the adversary (COWBOY 2) for BFM execution and flight path de-confliction. All training rules were briefed in accordance with (IAW) Air Force Instruction (AFI) 11-214. The MP covered a1157 WG, 53 WG, 422 TES, and Weapons School Special Interest Items (SIIs) (Tab V-5.4).

c. Preflight.

RAPTOR 2's aircraft was not ready at step time. 422 TES supervision elected to launch the MP without RAPTOR 2. RAPTOR 2 would join the MP and COWBOY 2 in the airspace if able. The MP received a step brief from 422 TES Operations Officer; and he proceeded to the MA. Aircraft forms were reviewed via the Portable Maintenance Aid (PMA) with the dedicated crew chief (DCC). Neither the MP nor the DCC noted any discrepancies. Aircraft preflight was conducted IAW T.O. 1F/A-22-1CL and was uneventful (Tab V-5.6).

d. Mishap Sequence.

The following summary of events was compiled via a combination of witness testimony, Technical Order (T.O.) data, technical reports, and Crash Survivable Memory Unit (CSMU) data. This CSMU data is very complete and covers the entire mishap sortie, along with the entire first sortie of the day, and approximately the last 20 minutes of a previous flight. There are no indications the data is corrupt.

At 1421:36L the MP began starting engines. Both engine starts were normal. At 1424:08, the MP performed a Flight Control System (FLCS) sweep (Tab CC-4). This sweep is to ensure that any air in the hydraulic lines is purged and the hydraulic fluid is warmed up. Large amplitude inputs were observed in Pitch, Roll, and Rudder commands lasting for 7 seconds. Following the FLCS Sweep, the MP performed an Initiated FLCS Built-in Test (FLCS IBTT). At 1425:37 the FLCS IBTT passed (Tab CC-4). All other remaining checklist items in the Before Taxi checklist were accomplished. The only issue precluding takeoff was that the MA indicated low Stored Energy System (SES) pressure (Tab V-5.7). This situation is not unusual.

The SES uses fuel and pressurized air to provide starting power for the Auxiliary Power Unit (APU). The SES will indicate low (<90%) if a large amount of fuel and pressurized air is used during the start sequence. An "SES LOW" indication appears on the Integrated Caution and Warning (ICAW) display. The Air Recharge System (ARS) will recharge the SES after an eight minute purge cycle then begin charging the SES for a 10 minute cycle. Several purge/recharge cycles may be required depending on the recharge requirements. The MA displayed an

"SES LOW" ICAW immediately after APU start (Tab V-5.6).

IAW local procedures, the MP initiated an APU restart following the second engine start. This restart interrupts the normal cooldown mode of the APU and prevents APU shutdown

(Tab V-5.6). This is done to preclude another APU start (depleting more SES pressure) if the Thermal Management Mode (TMM) is required for fuel cooling. In order for TMM to operate, the APU must be running. Following the eight minute purge cycle, at 1429:01, a Fault Reporting Code (FRC) reported an ARS failure (Tab CC-4). This FRC is not apparent to the pilot. The only indication to the pilot is the SES does not recharge. The MP testified that the SES pressure was 75%, well below the 90% required for takeoff. This would not preclude taxi due to the expected purge/recharge cycle. All Before Taxi checklist items were accomplished and the MP taxied to runway 03 (Tab V-5.7).

From 1434:06 to 1438:06, the MP taxied to End of Runway (EOR). By this time, the purge/recharge cycle of the SES should have shown some improvement. However, the MP noted only a small increase from 75% to 79% (Tab CC-4) (TAB V-5.8). In an attempt to increase the speed/efficiency of the ARS recharge, the MP selected Air Source-Left at 1441:11. He also began coordinating for maintenance assistance, called a "redball", with 422 Operations. RAPTOR 2 was still at the operations desk and recommended that he select TMM in an attempt to increase the speed/efficiency of the ARS. At 1457:36 TMM was selected (Tab CC-4) (Tab V5.9). Within eight minutes, the MP determined that neither Air Source-Left nor TMM was having the desired effect and required corrective maintenance. From 1505:36 to 1509:36 the MP taxied back to maintenance for a manual SES recharge using a ground SES cart (Tab CC-5). The fitting for the SES recharge cart is located in the nose gear wheel well and requires both engines to be shutdown (Tab CC-5) (Tab V-5.9) The MP elected to leave the APU running during engine shutdown, which is normal.

Three aspects of APU operation must be understood at this point. While on the ground, the APU will only shutdown if: 1) the APU is manually turned off by the APU switch, or 2) the APU is turned off via the APU fire light, or 3) TMM is exited. Normal APU shutdown on the ground consists of two phases, cooldown followed by spooldown. During cooldown, the APU continues to run and supply power, albeit in a reduced power mode. Cooldown lasts approximately 20 seconds (Tab BB-3 through BB-7). Finally, as previously discussed, the pilot can stop APU cooldown by commanding restart.

The following is critical in the mishap sequence. At 1515:05 the left engine was shutdown, and at 1516:16 the right engine was shutdown. The shutdown of the second engine effectively turned TMM off. Therefore, the APU was commanded to enter cooldown (Tab CC-5). Power to the aircraft was supplied via the Permanent Magnet Generators (PMG) until engine Revolutions Per Minute (RPM) dropped from idle (73%) to 53%. Once below 53%, the PMGs no longer supplied power and were removed from the electrical power system. At this point, the power state of the aircraft was changing.

Once the APU was commanded to begin shutdown (via cooldown then spooldown), the APU run state changed from 1 (run) to 0 (off). The first stage of APU shutdown is cooldown. During cooldown, the APU reduces its electrical power output in preparation for the complete removal of power. This reduction in power reduces the effective APU generator output from 22 kilowatt (kw) to 5 kw. When the APU is supplying aircraft power in the Skw mode, the aircraft power state is called the "SES power state" (Tab BB-3 through BB-7). Once the RPM dropped below 53%, main generator output was 0 (off) on the right engine, the APU RUN light began to flash as an indication of APU cooldown. More importantly, the aircraft had entered the SES power state. At the first indication of a flashing APU RUN light, the MP initiated an APU restart (Tab V5.10).

SES power state is apparent on CSMU data. On the last frame of CSMU data, all four converters on Power Distribution Centers (PDC) 5 and 6 (270 volts DC Buses 3 and 4) indicated "good". This indicates good APU generator operation. However, it does not show whether the APU was operating in 22 kw (run) or 5 kw (SES) mode. The last frame of CSMU data also showed the removal of 115 volts AC Inverter Signals from PDC 7 and 8. These inverter signals are passed via PDC 5 and 6 (which are powered regardless of APU run mode) and show the removal of 115 volts AC power. This combination of converter/inverter signals clearly shows that the APU was operating in the 5 kw SES mode (Tab CC-5) (Tab BB-3 through BB-7). In the SES power state (ground operations only) the FLCS does not receive power. The next paragraph describes how electrical power is removed from the FLCS while in the SES power state.

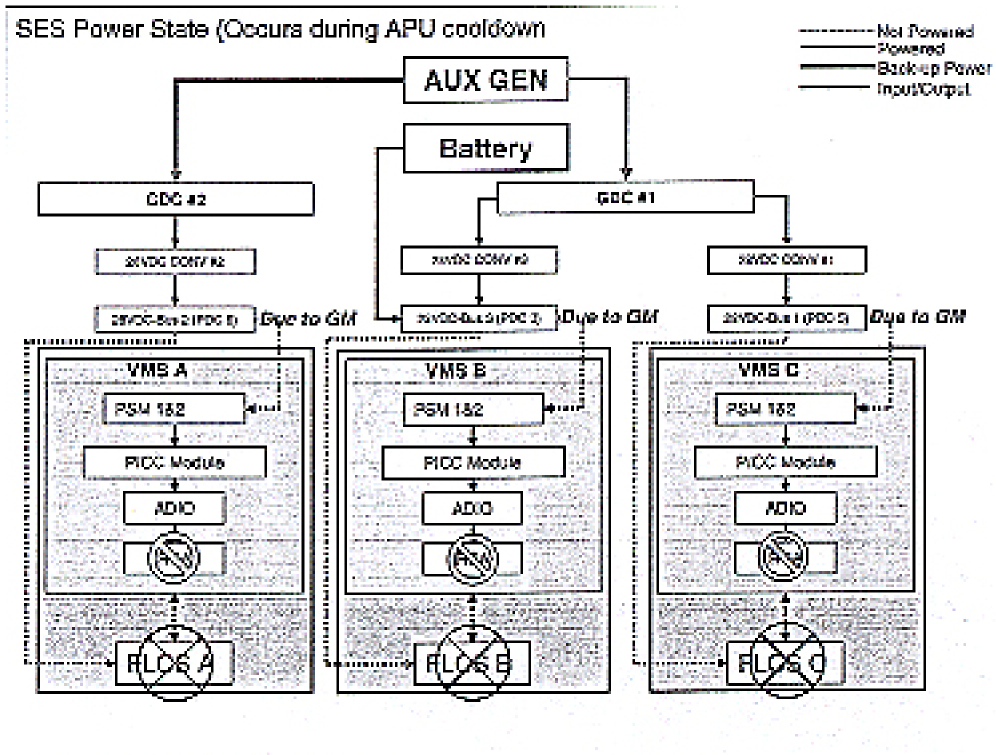

Figure 1-SES Power State-Power Distribution to FLCS (Created by AM Pilot Advisor)

While the APU is in SES mode (aircraft in SES power state) of operation (5 kw output), both Generator Distribution Centers (GDC) remain powered. In addition, 28 volts DC Buses 1, 2, and 3 receive power from their associated 28 volts DC converters. Global Management (GM), software control for all aircraft operations, removes power to the FLCS computers and portions of the Vehicle Management System (VMS). Each of the three FLCS branches has its own associated VMS. Within each of the three VMSs, is a Rate Sensor Assembly (RSA). RSAs measure angular acceleration in all three axes, pitch, roll, and yaw. These RSAs require power to provide a valid output (Tab BB-3 through BB-7).

Once GM sensed the aircraft was in SES power state (on the ground), power was removed from Power Supply Modules (PSM) 1&2 in the VMS. Therefore, no power was supplied to the Processor Interface Controller and Communication (PICC) module, the Analog Digital Input/Output (ADIO), and the associated RSA in turn. We now know that power was removed from the RSAs. The length of time they were without power is an important factor.

To avoid another SES discharge for APU start, the MP kept the APU running during the SES recharge process. As stated earlier, at the first indication of a flashing APU RUN light, the MP initiated an APU restart (Tab V-5.10). By commanding the APU to run during the cooldown sequence, several things happened in terms of aircraft power. The APU run state was changed from 0 (off) to 1 (run). The cooldown sequence was cancelled. Finally, the SES mode (5 kw) of operation was upgraded to the APU run mode (22 kw). Power was immediately restored to the VMS and the FLCS computers. Based on the fact that the last frame of data showed the first indication of APU cooldown (SES power state) and the pilot's testimony of commanding an APU restart at the first indication of a flashing APU RUN light, the time power was interrupted to the RSAs was less than one second. This less than one second power interruption to the RSAs was a critical factor in the mishap sequence.

This momentary interruption of power to the RSAs at approximately 1516:20 caused all three to "latch". This latched state nullified their output (Tab CC-5). See Section 6a for a description of RSA latching. CSMU data confirms RSA latching. Prior to the power interruption at approximately 1516:20, all three RSA outputs were correct (Tab CC-5). At 1522:45 the right engine was commanded to start by moving the throttle from OFF to Idle. This command restarted CSMU recording. From the first frame of data at 1522:45 to the last frame of data at aircraft impact, all three RSAs showed a 0.0 output. Continuous 0.0 output indicates a latched RSA (Tab CC-8). Unfortunately, the MP was unaware of this condition (Tab V-5.10 through V-5.13).

The FLCS uses data comparison to determine if a component is not working properly. This is called the Periodic Built in Test (PBIT). Basically, if one value differs significantly from the other two values, it is considered invalid. After one failure, the two remaining values are checked against expected output. After two failures there is generally no further fault monitoring. In this case, all three RSAs showed the same 0.0 output and were accepted as correct. Neither the PBIT nor the Start-up BIT (SBIT) would have detected this fault. The bottom line is that there is no automatic warning of a triple RSA failure. The only way to detect this fault is via a pilot initiated FLCS IBTT (Tab J-12, J-30).

At 1522:45 the right engine was started, and at 1523:21 the left engine was started. Engine startup was normal. Once again, the MP performed an APU restart preventing APU shutdown. At 1524:03 a short one second cycle of the flight controls was observed similar to a quick "stir the stick" motion. There was no indication of a pilot initiated FLCS IBIT. With the exception of the FLCS IBIT all pertinent checklist procedures were accomplished (Tab CC-6) (Tab V-5.10).

T.O. 1F/A-22A-1 requires a FLCS IBIT prior to flight and warns the pilot to re-accomplish a FLCS IBTT if the aircraft is "shutdown" (Tab BB-2). However, T.O. guidance concerning FLCS IBIT and aircraft power supply/states is ambiguous and/or incorrect. Therefore, the MP believed another FLCS IBIT was unnecessary (Tab V-5.10, 18, 19). Refer to Section 13c(1) for an expanded discussion of T.O. adherence, correctness, and applicability.

At 1531:30 the MP taxied to EOR, arriving at 1535:30. MA appeared normal to the EOR ground crew (Tab V-1.5). All flight control surfaces were in their normal position (Tab CC-6). At 1537:30 the MP taxied out of EOR preparing for takeoff. All Before Takeoff checklist items were accomplished (Tab CC-6) (Tab V-5.11). Nine seconds after departing EOR the MP shutdown the APU. He was cleared "into position and hold." The APU shutdown sequence was complete (cooldown and spooldown) at 1537:53. At 1539:26 throttles moved from both idle to Mil power. At 1539:34, MP released brakes (Tab CC-6).

The following description is based on a combination of CSMU data and video recreation derived from CSMU data. All indications were normal throughout takeoff roll. At 1539:52 the MP initiated rotation at 140KCAS. Angle of Attack (AOA) was 0.7 degrees and Beta (sideslip) was 1.7degrees nose right. Left and right weight-off-wheels occurred at 1539:58 (Tab CC-7). The MP stated that the MA "jumped into air". This was the result of higher than normal horizontal tail deflection. The MP stated that this was the first indication of abnormal operation (Tab V-5.13).

Without RSA data, the FLCS computer wasn't receiving angular acceleration feedback telling the FLCS computers how the aircraft was reacting to the pilot's stick/rudder inputs. The only information fed to the FLCS computers was the position of the flight control surfaces. This situation was recreated in the handling qualities simulator at Edwards AFB using the highly experienced F/A-22 test pilots. Without RSA data, all pilots crashed in the first few of seconds of flight. High stick sensitivity/over-control was the norm. The test pilots' conclusion was "the aircraft is completely uncontrollable without any angular acceleration/rate feedback to the FLCS" (Tab J-9).

Immediately after the MA became airborne, it yawed into the wind (nose right) with approximately 3 degrees of sideslip. The climb continued to be relatively stable varying between five and eight degrees of nose-high pitch. Through timely pilot input, the nose right yaw rate was arrested and began to yaw aggressively left. At the same time, power was reduced to approximately 45% for approximately two seconds. The MP testified that this was in reaction to the jet not "flying like an airplane." The MP did not consider a high speed abort because he believed he could fly the MA out of these yaw transients. The aircraft continued to yaw left to a sideslip angle 15 degrees. Due to his low altitude, the MP selected MAX power in an attempi to climb. After another large yaw oscillation to right (22 degrees of sideslip) MP reduced power back to military (MIL) for the remainder of the flight. The MP still felt he could fly his way out of this. The MP had not reached his ejection decision-yet (Tab CC-7) (Tab V-5.14).

The MP testified that his ejection decision is based on three criteria: 1) aircraft is not flying in coordinated flight, 2) the aircraft is not correctly responding to control inputs, and 3) the aircraft is progressing to a position that is unrecoverable either in pitch or roll (Tab V-5.15). The MP's well thought-out ejection decision prevented a probable fatality.

The landing gear was still down. Because the airspeed was continuing to climb and the fact that the aircraft was not flying well in its current configuration, the MP raised the landing gear. Immediately after landing gear retraction, the jet started to pitch-up, roll right, and yaw left. Sideslip peaked at 31 degree nose left. The right roll rate could not be arrested by stick and rudder inputs--the MA was no longer responding to the MP's flight control inputs. At 1540:09, 11 seconds after becoming airborne, the CANOPY UNLOCK ICAW asserted indicating ejection (Tab CC-8) (Tab V-5.15).

The MP stated that he was still trying to fly the aircraft with his right hand and pulled the ejection handle with his left. The MP's recollection of the events leading up to his ejection decision was accurate-almost an exact reiteration of CSMU data. Aircraft parameters at the time of the CANOPY UNLOCK ICAW are as follows (Tab CC-8):

- Angle of Attack: -4.4 degrees
- Sideslip: -39.0 degrees (nose left) • Pitch : 25 degrees nose up
- Roll: 56 degrees ring wing down (continuing to roll more right wing down)
- Magnetic heading: 002
- Airspeed: 210 Knots Calibrated Airspeed (KCAS)
- Altitude: 2360' (approximately 500 feet above the ground)

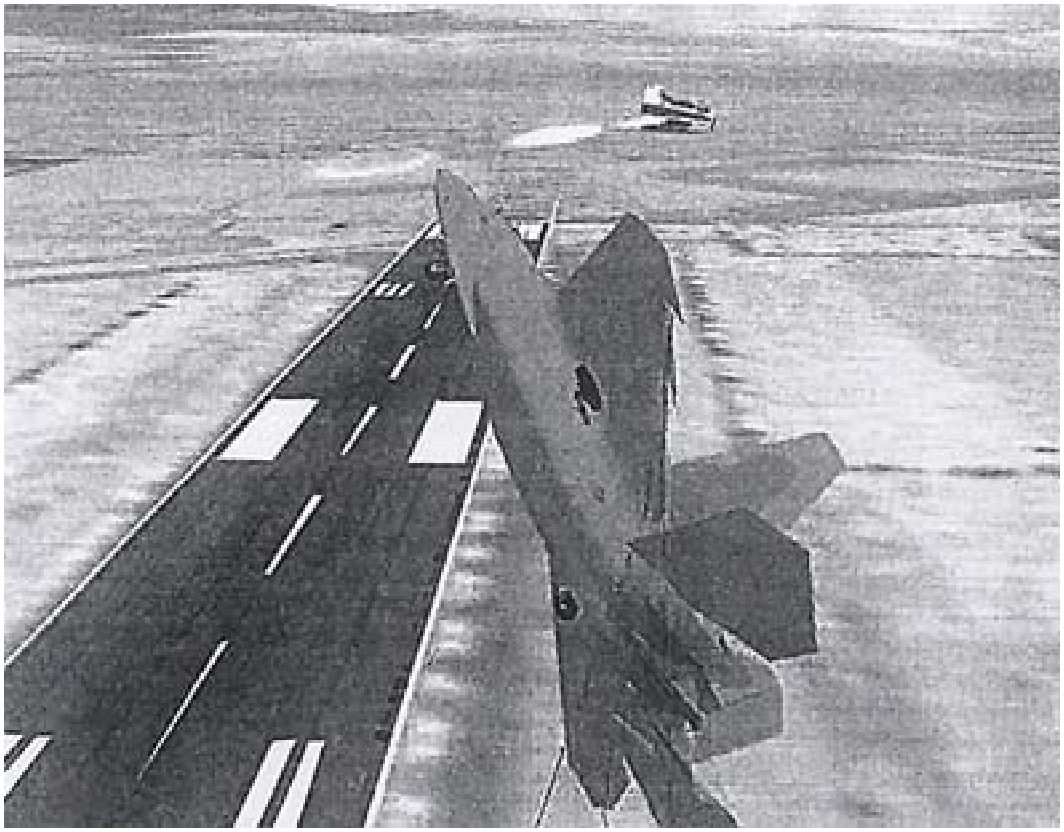

Figure 2 — Recreation of Aircraft Parameters at Ejection (Tab S Video)

The MP suffered minor abrasions to the neck during the ejection (Tab B-3). See section 4f for a discussion of the ejection seat performance.

Following the MP's ejection, the MA continued to simultaneously roll right and pitch further nose up. The MA continued to a near inverted attitude, and pitched nose up, essentially performing a "Split-S" and impacted the runway going backwards. The last frame of CSMU data recorded the following parameters (Tab J-23):

- Angle of Attack: 90 degrees
- Sideslip: -45.0 degrees (nose left)
- Pitch : 35 degrees nose up
- Roll: 71 degrees left wing down
- Magnetic heading: 223

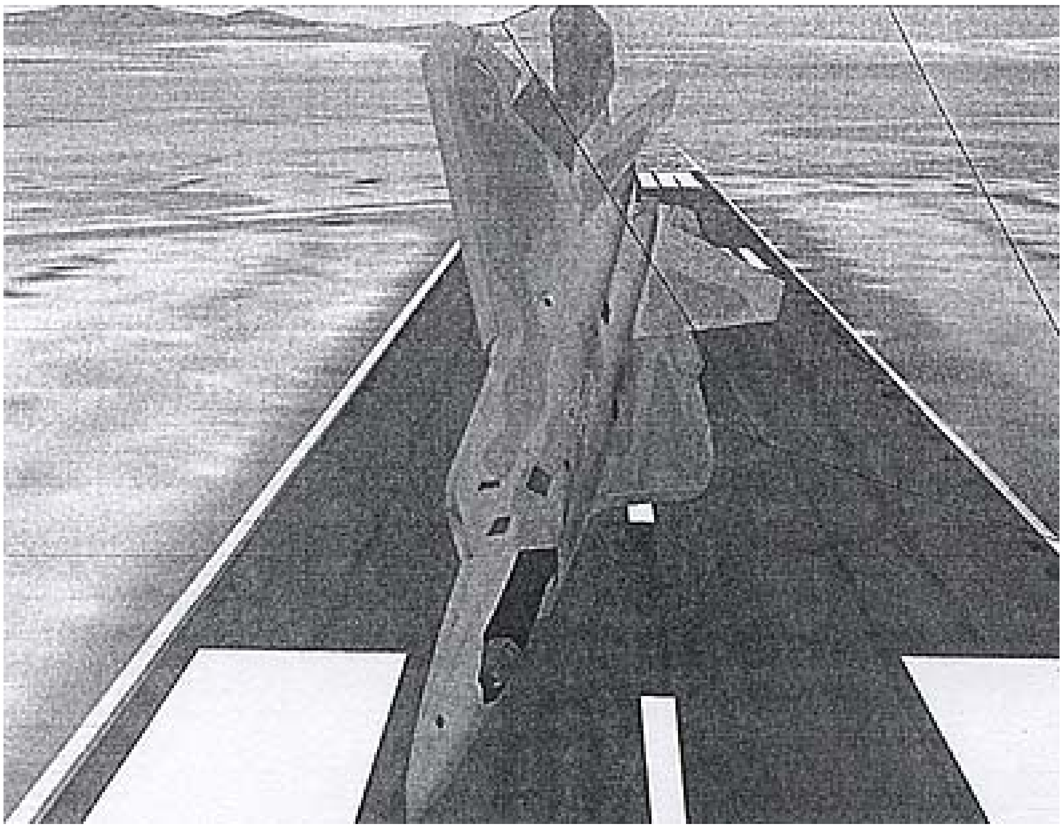

Figure 3 — Recreation of Aircraft Parameters at Impact (Tab S Video)

e. Impact.

Aircraft F/A-22A, S/N 00-4014, impacted the ground on initial takeoff at 2340:12Z/1540:12L (Tab J-23) at 36 degrees and 14.79 minutes north and 115 degrees and 01.41 minutes west, Nellis AFB, Nevada (Tab C-3). In addition to the loss of the aircraft, other government property that was damaged included a BAK-12 arresting cable, a runway guide sign, a runway light and runway 03R. MA broke into several pieces leaving a debris field scattered over the departure end of runway 03R, the runway overrun and ground area beyond the departure end.

f. Life Support Equipment, Egress and Survival.

The MP initiated ejection at 2340:09Z/1540:09L during an uncommanded right roll at approximately 2,360 feet MSL, 500 feet AGL (Tab CC-8). The parachute deployed normally (Tab V-5.16).

The Air Force Safety Center at Kirtland AFB, NM evaluated the following Emergency Escape Sequencing System (EESS): modified ACES II ejection seat (S/N 225014), two Thermal Battery Ejection Seat Initiators (S/Ns 50 & 36), two Electro-Explosive Devices (EED) (S/Ns 1678 & 1670), the Canopy Jettison Rocket Motor (S/N 19), Inertia Reel Gas Generator (S/N 11134), Inertia Reel EED (S/N 125), Primary Parachute Mortar Cartridge (S/N 9269), Back-up Parachute Mortar Cartridge (S/N 9276), Drogue Deployment Mortar Cartridge (S/N 31563), the CKU-5B/A Ejection Seat Rocket Catapult, the Gyro Spin-up Cartridge (S/N 16443), the Vernier Rocket Motor (S/N 11490), the Harness Release Cartridge (SIN 24443), two Drogue Severance Assemblies (S/Ns 3736 & 3701), two 1.15 Second

Delay Reefing Line Cutters, the 4.0 Second Delay Locking Cord Cutter, the Recovery Sequencer (S/N 1199-1389), and two Universal Water Activated Release System (UWARS) parachute releases (Tab H-3 through H-5).

In the opinion of the evaluators, the EESS and all pyrotechnic components functioned properly during the ejection in the Mode I range (Tab H-6).

g. Search and Rescue.

The MP ejected safely and sustained only minor injuries. Mongoose 01, an HH-60G transitioning in the traffic pattern, landed on runway 03R to ensure the MP had not sustained significant injury. The MP was transported by ambulance to Mike O'Callahan Federal Hospital where he received evaluation and treatment. The MA impacted runway 3R and was completely destroyed. The crash and resulting debris field were confined to Nellis AFB property. Fire response was swift, and the fire was extinguished.

h. Recovery of Remains.

There were no fatalities as a result of this mishap.

5. MAINTENANCE

a. Forms Documentation.

The 422 Aircraft Maintenance Unit (AMU) maintained the aircraft forms for the F/A-22A Raptor on an Integrated Maintenance Information System (IMIS) database server which is accessed through a portable computer called a Portable Maintenance Aide (PMA). The PMA interfaces with the aircraft for maintenance, servicing, and diagnostics. The Pratt & Whitney F119-PW-100 engine is maintained by Pratt & Whitney under a contract support system in which maintenance is performed in a technical support concept. The data can also be accessed via the Core Automated Maintenance System (CAMS) which is a computer system used for maintenance management and trend analysis. The following documents (which are used in lieu of 781 series forms) were thoroughly reviewed and provided pertinent information:

- Electronic IMIS aircraft records
- CAMS print out
- Aircraft Jacket File
- Electronic IMIS engine records
- Time Change Records
- Weight and Balance Handbook
- AFT O Form 95
- Support Equipment Form 244
- Avionics and Weapons Log Books

Time Compliance Technical Orders (TCTO) status was reviewed. Of relevance to the mishap is TCTO 1F/A-22A-654, which would have replaced all three RSAs, Part Number 553500-O1, installed on MA with Part Number 553500-02 which is an upgraded RSA. The TCTO was not yet accomplished and parts were on order. The grounding date for this TCTO was 15 May 2006. RSA serial numbers and part numbers were extracted from the IMIS Hardware and Software Configuration pages from the PMA and the CAMS print out. The MA's RSA part numbers were 553500-01, serial numbers 002, 009, 026 (Tab U-3, U-4).

TCTO 1F/A-22-574 installed Operational Flight Program (OFP) 3.1.2 in June 2004. This OFP load incorporated an APU restart feature. APU restart overrides the APU shutdown in order to help the SES charge and Thermal Management System (TMS) timeline. The change was tested in Lockheed Martin Aero (LMA) Vehicle System Simulator (VSS). RSA units were not installed during testing of the APU re-start mode.

In addition, a new OFP, version 3.1.3, was loaded on the aircraft on 14 December 2004 under TCTO 1F/A-22-747. The changes integrated on this version did not affect the flight control system (Tab BB-9, BB-10). The OFP was loaded and tested by LMA personnel and included regression testing with FLCS IBIT. As of 25 December 2004, other F/A-22s with this OFP have flown 72 sorties and 104 flight hours without any FLCS problems (Tab CC-9 through CC-11). OFP load 3.1.3 was not a factor in the mishap.

Engine S/N 730052, position #1 had 190 total operating hours and was installed on the aircraft on 22 November 2004. Engine S/N 730036, position #2 had 260 total operating hours and was installed on the aircraft on 10 November 2004. Prior to installation on aircraft 4014, Pratt & Whitney performed a reliability centered maintenance retrofit to engines S/N 730052 and 730036. This retrofit consisted of 18 TCTOs which required disassembly of the engines. Engine records were reviewed and were unremarkable (Tab D-5).

b. Inspections.

All scheduled inspections were satisfactorily completed.

c. Maintenance Procedures.

With the exception of not to verifying/re-accomplishing a FLCS IBTT after engine restart, maintenance procedures were sound and in IAW USAF directives. See 13c(4) for discussion of FLCS IBIT.

d. Maintenance Personnel and Supervision.

Maintenance training records consisting of AF Form 623As, Career Field Education and Training Plans, AF Form 797s, and Special Certification Rosters were reviewed for the ground crew involved with the MA.

Preflight servicing of the aircraft, supervision, and performance of all personnel was within current directives. All training and certifications were current. Upgrade training and testing was progressing well for all airmen concerned. Personnel assigned to the MA were trained and had the necessary skill level and qualifications to perform assigned duties. Inadequate technical data regarding power modes during APU operation was a factor and is addressed in 13c(4).

e. Fuel, Hydraulic and Oil Inspection Analysis.

A review of fluid analysis records and accident fluid analyses on the aircraft, engines, and support equipment showed normal results (Tab D-7 through D-17).

f. Unscheduled Maintenance.

The aircraft had experienced FLCS discrepancies, not including RSA failures, which were repaired. These discrepancies were not a factor in the mishap. SES problems appeared throughout the recent history of the aircraft and are a fleet-wide occurrence.

6. AIRCRAFT AND AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS

a. Condition of Systems.

The MA had flown 146 sorties of 176 sorties attempted and 150.4 hours since 29 May 2003. 95 sorties were Code 1 (no discrepancies), 35 sorties were code 2 (flyable discrepancies), and 16 sorties were code 3 (grounding discrepancies). Reported discrepancies were recorded and all discrepancies were corrected and properly documented (Tab CC-10, CC-11).

With the exception of the canopy and ejection seat, the MA was intact at impact. CSMU data shows all relevant systems (control surfaces, engines, navigational systems, instruments, warning systems, fuel, lubrication, electrical, hydraulic, pneumatic, avionics, communications, and environmental control) were normal with the exception of the three latched RSAs (Tab CC-4 through CC-9).

RSA serial numbers and part numbers were extracted from the IMIS Hardware and Software Configuration pages in the PMA and the CAMS print out. All three RSAs were initial production model -101 versions with part numbers 553500-01, serial # 2, 9, and 26. LMA mishap analysis revealed that two of the three RSAs installed on aircraft 4014 were returned to BAE systems for repair: # 9 due to latching and # 26 due to shock sensor. They were repaired and returned to service in the -101 configuration and installed on the MA on 6 May 2003.

LMA was aware of occasional RSA latching at startup since 2002. This latching condition is due to a pin used by the manufacture to get the unit into the test mode. This pin connects to a Universal Asynchronous Receiver Transmitter (UART) chip. The UART is looking for a leading edge 5 VDC square-wave trigger to get the unit into test mode. With this pin left "floating" the RSA can latch in the test mode on power-up or cycled power.

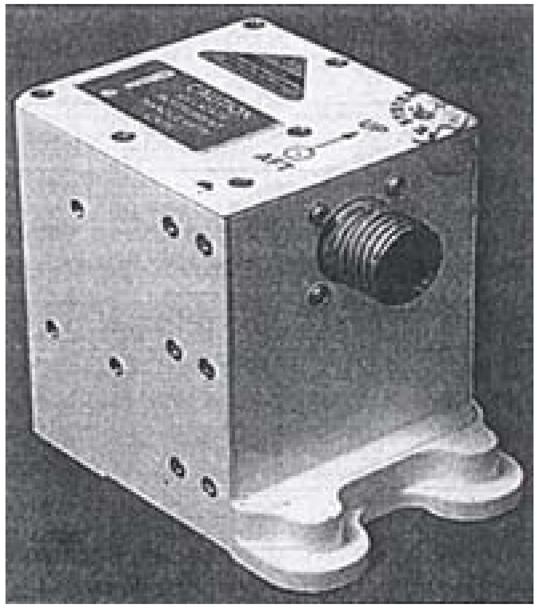

Figure 4 — RSA

Approximately 20 -101 RSAs had been returned to the supplier for suspected latching. Most had been single failures with one double RSA failure. All occurred on the ground and had been detected by built-in-test. LMA determined the probability of a catastrophic airborne triple RSA failure to be extremely low and developed a latching fix. This involved adding a pull-up resister to give a constant Sv signal to the UART, ensuring the leading edge trigger will never be seen by the UART. In June 2004, Lockheed Martin submitted a charge request which added the latching fix to an ongoing RSA upgrade plan. The improved RSA, designated the -103, was to be gradually retrofitted in all F/A-22s through TCTO 1F/A-22A-654 (Tab J-11, J-26).

The F/A-22 Systems Program Office (SPO) did not conduct an internal safety review of the -101 latching issue or proposed fix (Tab J-11). The SPO's technical lead for flight controls, which include RSAs, had no knowledge of either latching problems or the fix until after the mishap (Tab V-6.1). The SPO has since implemented procedures to ensure a proper review of change requests (Tab V-16.5).

b. Testing.

Post-mishap testing revealed the potential for triple RSA latching. After MA's CSMU data showed zero output from all three RSAs, LMA Air Vehicle Systems engineers conducted tests to better characterize what had previously been described as a random tendency to latch at startup. Extensive power cycling tests were performed in the VSS at LMA Fort Worth. The VSS had been used in the past to duplicate the latching characteristic of the -101 RSAs.

The -101 RSAs were installed in an F/A-22 flight control system simulator and the power switched (on-off-on) over a range from a few milliseconds to 16 seconds. Testing determined that the probably of -101 RSA latching depends on the length of time power is lost: less than 1.6 seconds the failure almost always (99%) occurs, from 1.6 to about 3.5 seconds the chances are 50%, and from 3.5 seconds on the latching do not occur. -103 RSAs did not latch during the testing (Tab J-10).

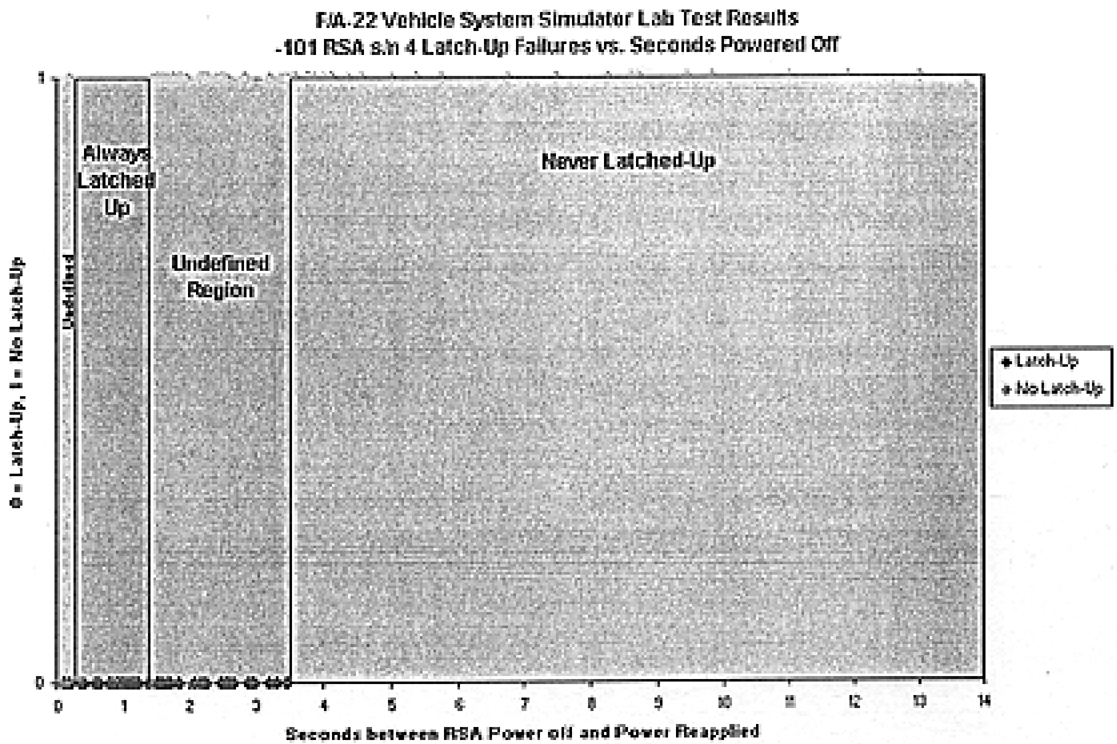

Figure 5: Data was taken in the VSS on a -101 configuration RSA to identify variables affecting the latch state. The data was taken by removing power to the RSA, then reapplying power and checking to see if the event resulted in a latched state. The span time from power removed to power reapplied is plotted as the x-axis. The state of the RSA is plotted as the y-axis (0 for latched; 1 for normal state) (Tab J-28).

7. WEATHER

a. Forecast Weather.

Forecast weather for Nellis AFB on 20 December 2004 called for variable wind direction at six knots. Sky conditions were to be clear with a visibility of seven statute miles. The altimeter setting was 30.05 inches. Between 20 and 21 December 2004 the only significant change in the forecast indicated winds would be out of the north at six knots, and a scattered layer of clouds would be present at 20,000 feet (Tab F).

b. Observed Weather.

The weather prior to Raptor O l's scheduled takeoff revealed winds variable at three knots, visibility 40 statute miles, a scattered cloud layer at 20,000 feet and an altimeter setting of 29.90 inches. A special observation less than two minutes after the mishap indicated the same report with the only difference being the winds from 070 at four knots (Tab F).

c. Space Environment.

Not Applicable.

d. Conclusions.

Weather was not a factor in this mishap.

8. CREW QUALIFICATIONS

The MP is an experienced instructor pilot and dual qualified in the F-15C/D and the F/A-22. He had 2,001.2 hours in the F-15C/D, 1,111.6 of which were logged as an instructor. His total time in the F/A-22 was 54.6 hours, and 39.6 of those were as an instructor. The MP's possessed 2150.2 total military flying time. He was current and qualified to perform the duties planned for the mishap sortie (Tab G-7). Recent flight time is as follows (Tab G-4):

F/A-22	Hours	Sorties
30 days	6.9	4
60 days	17.0	11
90 days	24.1	15

F-15C	Hours	Sorties
30 days	0.5	1
60 days	3.0	3
90 days	12.3	9

F- 15D	Hours	Sorties
30 days	0.0	0
60 days	0.8	1
90 days	2.1	2

9. MEDICAL

a. Qualifications.

The medical and dental records of the MP were reviewed. He was medically qualified for flying class II duties at the time of the mishap. He was not on a waiver. The medical and dental records of maintainers involved with the MA were reviewed with no findings (Tab X-3).

b. Health.

The MP's and maintainers' health were not contributing factors to this mishap (Tab X-3). Postejection evaluation of the MP revealed only minor injuries that required no additional medical treatment (Tab X-2).

c. Toxicology.

Post-mishap analysis of carbon monoxide, blood ethanol and drug urine screens revealed no abnormalities. This was accomplished on the MP and the key maintainers (Tab X-3).

d. Lifestyle.

There is no evidence that unusual habits, behavior, or stress contributed to the accident (Tab V-5.3).

e. Crew Rest/Crew Duty Time.

The MP met all crew rest requirements (Tab V-5.3).

10. OPERATIONS AND SUPERVISION

a. Operations.

The 422 TES is comprised of all highly experienced Instructor Pilots. The unit requires this level of experience to execute complex operational test scenarios. There were no indications that either experience or operations tempo were a factor in the mishap.

b. Supervision.

Operations supervision complied with all governing directives. Supervision was not a factor.

11. HUMAN FACTORS ANALYSIS

All human factors listed in AFPAM 91-211 were reviewed. No human factors played a role in this accident (Tab X-3).

12. ADDITIONAL AREAS OF CONCERN

There are no additional areas of concern.

13. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Primary Operations Directives and Publications.

(1) T.O. 1F/A-22A-1

(2) T.O. 1F/A-22A-1CL

b. Maintenance Directives and Publications.

(1) AFI 21-101-Aerospace Equipment Maintenance Management

(2) AFI 21-101 NAFB SUP 1 dated 26 Mar 2004- Red Ball Procedures

(3) AFI 21-124--Air Force Oil Analysis Program

(4) PMA T.O. 1F/A-22A-- Launch Checklist

c. Known or Suspected Deviations from Directives or Publications.

(1) Mishap Crew.

T.O. 1F/A-22A-1 (dash-1) was the relevant governing directive for the MP. It provides both general knowledge of the aircraft and specific operating procedures. With regards to the requirement for a FLCS IBIT and Flight Control System power, the dash-1 is ambiguous and incorrect (Tab BB-2).

Page 2-20 contains the following warning under Normal Procedures in the Before Taxi Checklist:

> *"Do not take off without completing a successful FLCS IBIT. If the aircraft is shutdown during ground operations a FLCS IBIT must be reaccomplished."*

The MP completed a successful FLCS IBIT after the original engine start. The need for FLCS IBIT after engine restart is unclear because definition of "shutdown" is ambiguous. Eleven of 18 F/A-22 pilots surveyed believed that "shutdown" means all power is removed from the aircraft (Tab CC-3). Because the APU remained on, the MP believed the FLCS never lost power, and he had not shutdown. This belief is based, in part, on the following dash-1 passage and is reinforced in pilot systems academics (Tab BB-3).

> *"The FLCS is operational any time 28 volt DC power is available on the aircraft, except while on the ground when the battery is the only source of power."*

This is incorrect. This investigation identified several aircraft power states that are not mentioned in the dash-1. The most important is the SES power state. During the SES power state 28 volt DC power is available from the APU, but the FLCS is not powered. The only time the aircraft enters this SES power state on the ground is during SES start and APU cooldown. The dash-1 describes cooldown as follows:

> *"During cooldown the APU continues to run, the APU RUN light flashes, the auxiliary generator supplies power, the auxiliary hydraulic pump is depressurized, the APU bleed air to the ECS is terminated. Cooldown only occurs during ground operation."*

This statement further reinforces the belief that the FLCS remains powered. The statement that "the auxiliary generator supplies power" is only partially true. While the auxiliary generator does continue to supply power, it is only 5 kw instead of the normal 22 kw. This reduced power output is not addressed in the dash-1. It is during this period (the SES power state) of reduced APU power output that the FLCS is not powered. This contradicts previously cited dash-1 information.

This misunderstanding was widespread. F/A-22 pilots, maintenance personnel, Air Force Engineering and Technical Services (AFETS) experts, and avionics/electrics technicians interviewed during this investigation were unaware of the SES power state and the FLCS power ramifications (Tab CC-3, CC-13, V-9.1, V-11.2, V-15.1). This investigation finally found the information in the *Software Requirements Specification for the Electrical Power System Software of the F/A-22 Weapons System* provided by LMA through the SPO.

(2) Lead Crew/Others.

Not applicable.

(3) Operations Supervision.

Operations supervision complied with all directives and publications.

(4) Maintenance.

Compliance with the F/A-22 launch checklist under normal launch conditions was evident during the first launch attempt. The crew chief's suspected failure to verify a FLCS IBIT after engine restart warrants review. At this point in the operation, the crew chief is expected to return to the launch checklist. However, for this scenario, no directives specify a starting point on the checklist. According to the Chief of Quality Assurance and four Crew Chief trainers, the crew chief uses judgment and aircraft system knowledge to determine which events need to be reaccomplished. The belief that a system was previously checked and had not changed would explain the failure to re-accomplish the check (Tab CC-12).

The testimony of four crew chief trainers, four electrical/avionics specialists, five Air Force Engineering and Technical Services representatives, and two Field Training Detachment instructors with F/A-22 experience demonstrates a common belief in continuous FLCS power during engine shutdown with APU running. Technical data, checklists, and maintenance training courseware do not address potential for power interruption (Tab CC-13).

14. NEWS MEDIA INVOLVEMENT

On the day of and the day after the mishap, local media interest was high. All of the local news channels ran stories, and articles were written in two local newspapers. The Associated Press also printed reports not only covering the mishap, but also the F/A-22 fleet's return to the air. Public affairs released two statements. The first simply reported the incident, and the second advertised a public address to be accomplished by Major General Stephen Goldfein, Commander, Air Force Warfare Center (AFWC). At approximately 1430L on 22 December 2004, Maj Gen Goldfein briefed members of the media on the mishap and the investigation process. Since then, media interest has been minimal (Tab DD).

3 February 2005

STANLEY T. KRESGE, Colonel, USAF
President, Accident Investigation Board

STATEMENT OF OPINION
F/A-22 ACCIDENT
20 December 2004

Under 10 U.S.C. 2254(d) any opinion of the accident investigators as to the cause 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.

1. OPINION SUMMARY:

The Accident Investigation Board conducted a complete and thorough investigation of this mishap. In addition to interviews with the MP, maintenance personnel, and SPO personnel, the investigation reviewed technical evaluations, CSMU data, technical orders, and applicable academic material.

The cause of this mishap, supported by clear and convincing evidence, was an inoperative FLCS, resulting from a power interruption to the three RSAs, which rendered the MA uncontrollable. The MP was unaware of this condition because he did not perform an IBIT, the only means of identifying the problem. Failure to perform the IBIT was the result of ambiguous and incorrect Technical Orders and a mistaken belief in continuous RSA power availability.

2. DISCUSSION OF OPINION:

RSAs are a critical component of the F/A-22 flight control system. Their function is to provide angular acceleration (yaw, pitch, and roll) feedback so the flight control computer knows how the aircraft is responding to flight control inputs. During the mishap, the MA's three RSAs were "latched" and therefore not providing the necessary feedback. Simulator testing showed that in this condition, the aircraft is not flyable.

The MP was unaware of the flight control problem. The MA's flight control surfaces operated normally on the ground. The FLCS automatic PBIT is designed to compare the output of the three RSAs to determine if the output of one differs from the other two. If so, it warns the pilot. PBIT cannot identify that all three RSAs are latched because their output (zero) is the same. The only way to discover the problem is to perform a FLCS IBIT.

The MP performed a FLCS IBIT after engine start during the first attempt of the mishap sortie. The FLCS was operating normally until the MP shutdown both engines to allow maintenance personnel to service the Stored Energy System (SES). The MP ensured the APU remained running while the engines were off. During engine shutdown, all three RSAs latched. The MP did not perform a FLCS IBIT after restarting engines.

The F/A-22 Pilot Checklist requires a FLCS IBIT after engine start. T.O. 1F/A-22A-1 contains the following warning: "Do not take off without completing a successful FLCS IBIT. If the aircraft is shut down during ground operations a FLCS IBIT must be reaccomplished." The MP was aware of this guidance. However, because the APU was running while the engines were off, he believed that the FLCS received continuous power and did not consider the aircraft to be "shutdown". These beliefs were based on F/A-22 academic training, T.O. systems description, and are shared by most F/A-22 personnel we surveyed.

The F/A-22 maintenance T.O. requires the crew chief to verify FLCS IBIT after engine start. There is clear and convincing evidence that the crew chief did so after the first attempt engine start. It is uncertain what was said after the engine restart. However, there is no clear consensus on what the T.O. requires following the engines shutdown-APU running-engines restart sequence. Most maintenance personnel interviewed considered the FLCS IBIT optional because of continuous APU power.

Unfortunately, FLCS power is interrupted during APU cooldown when engines are below 53% RPM. There is clear and convincing evidence of the following events. The MP selected TMM in an attempt to correct the SES problem. With TMM selected, the APU enters cooldown mode when engines are shut down. OFP 3.1.2, installed in the MA in June 2004, gave the pilot the ability to override APU cooldown. The MP shut down the engines, experienced APU cooldown, then selected override. During the brief period when the APU was in cooldown and the engines were both below 53%, power to the RSAs was interrupted.

The MA contained 5VV50035-101 (-101) configuration RSAs. Post-mishap testing determined the probability of -101 latching depends on the length of time power is lost. If less than 1.6 seconds, latching almost always (99%) occurs. Between 1.6 to 3.5 seconds, the probability is 50%. Greater than 3.5 seconds, latching does not occur. There is substantial evidence that the MA's RSAs experienced a less than one second power loss, which almost guaranteed all three RSAs would latch.

Prior to the mishap, approximately 20 -101 RSAs had been returned to the supplier (BAE Systems) for suspected latching during ground power up. The failures have mainly been single RSAs, with one occurrence of dual failure. All occurred on the ground and detected by built in tests. A catastrophic triple RSA failure was considered nearly impossible. In June 2004, Lockheed Martin Aeronautics incorporated a fix to the latching problem into the new -103 RSA, to be eventually retrofitted in all F/A-22s. Based on the information available at the time, the retrofit plan was reasonable.

3 February 2005

STANLEY T. KRESGE, Colonel, USAF
President, Accident Investigation Board