UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION BOARD REPORT

F-22A, T/N 06-4125

3RD WING
JOINT BASE ELMENDORF-RICHARDSON, ALASKA

LOCATION: JOINT BASE ELMENDORF-RICHARDSON, ALASKA
DATE OF ACCIDENT: 16 NOVEMBER 2010
BOARD PRESIDENT: BRIG GEN JAMES S. BROWNE
CONDUCTED IAW AIR FORCE INSTRUCTION 51-503

EXECUTIVE SUMMARY

AIRCRAFT ACCIDENT INVESTIGATION

F-22A, T/N 06-4125
JOINT BASE ELMENDORF-RICHARDSON, ALASKA
16 NOVEMBER 2010

On 16 Nov 2010, at approximately 19:43:27 hours local time (L), an F-22A, tail number 06-4125, assigned to the 525th Fighter Squadron, 3rd Wing, Joint Base Elmendorf-Richardson (JBER), Alaska, impacted the ground during controlled flight approximately 120 nautical miles (NM) northeast of JBER. The mishap pilot (MP) did not attempt ejection and was fatally injured upon impact. The mishap aircraft (MA) was destroyed. There was no damage to private property. A damage cost of $147,672,000.00 includes the total destruction of the MA along with its internal stores.

The mishap occurred on a 3-ship night opposed surface attack tactics training mission, during the return-to-base portion of the mission while the MP was attempting to rejoin with his flight lead. At approximately 19:42:18L, the MA experienced an engine bleed air leak malfunction. The MP began a descent and retarded the throttles to IDLE power. At 19:42:53L, the MA entered a 240 degree roll through inverted, and the nose down (ND) pitch attitude increased. At approximately 19:43:24L, the MP initiated a dive recovery. Three seconds later, the aircraft impacted the ground in a left bank at approximately 48 degrees ND at a speed greater than 1.1 Mach.

The board president found, by clear and convincing evidence, the cause of the mishap was the MP's failure to recognize and initiate a timely dive recovery due to channelized attention, breakdown of visual scan, and unrecognized spatial disorientation.

Additionally, the board president found, by preponderance of evidence, organizational training issues, inadvertent operations, personal equipment interference, and controls/switches were factors that substantially contributed to the mishap.

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, if any, may not be considered as evidence in any civil or criminal proceeding arising from the 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.

SUMMARY OF FACTS AND STATEMENT OF OPINION
F-22A, T/N 06-0125
16 NOVEMBER 2010

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COMMONLY USED ACRONYMS AND ABBREVIATIONS

3WG	3rd Wing
AF	Air Force
AFB	Air Force Base
AFE	Air Flight Equipment
AFI	Air Force Instruction
AFIP	Air Force Institute of Pathology
AFPAM	Air Force Pamphlet
AGL	Above Ground Level
AIB	Aircraft Investigation Board
AK	Alaska
ATAGS	Advanced Tactical Anti-G System
BRAG	Breathing Regulator/Anti-G
Capt	Captain
CAUT	Caution
CIP	Core Integrated Processor
Col	Colonel
CSMU	Crash Survivable Memory Unit
DoD	Department of Defense
ECS	Environmental Control System
EOS	Emergency Oxygen System
EPS	Emergency Power System
FL	Flight Lead
FLCS	Flight Control System
FPM	Feet Per Minute
FPS	Fire Protection System
FRC	Fault Reporting Codes
FS	Fighter Squadron
ft	Feet
g	Gravitational Force
HUD	Heads up Display
IAW	In Accordance With
ICAWS	Integrated Caution, Advisory and Warning System
IFDL	Intra-Flight Data Link
IMIS	Integrated Maintenance Information System
IP	Instructor Pilot
IVSC	Integrated Vehicle Subsystem Controller
JBER	Joint Base Elmendorf-Richardson
JDAM	Joint Direct Attack Munitions
K	Thousand
KCAS	Knots Calibrated Airspeed
KTAS	Knots True Airspeed
kts	Knots
L	Local
LM-Aero	Lockheed Martin Aeronautics Company
Lt Col	Lieutenant Colonel
LWD	Left Wing Down
M	Mach
MA	Mishap Aircraft
Maj	Major
MAJCOM	Major Command
MFL	Mishap Flight Lead
MOA	Military Operating Area
MP	Mishap Pilot
MS	Mishap Sortie
MSL	Mean Sea Level
ND	Nose Down
NM	Nautical Miles
NOTAMS	Notices to Airmen
NVGs	Night Vision Goggles
OBIGGS	On-board Inert Gas Generating System
OBOGS	On-board Oxygen Generating System
OG	Operations Group
OPR	Officer Performance Report
Ops Tempo	Operations Tempo
ORM	Operational Risk Management
OSS	Operation Support Squadron
PA	Public Affairs
P&W	Pratt and Whitney
PAO	Polyalphaolefin
PACAF	Pacific Air Forces
PHA	Physical Health Assessment
PMP	Packaged Maintenance Plan
PR	Pre Flight
PSI	Pounds Per Square Inch
QA	Quality Assurance
RTB	Return-To-Base
RWD	Right Wing Down
SAR	Search and Rescue
SAT	Surface Attack Tactics
SII	Special Interest Item
SOF	Supervisor of Flying
TCTO	Time Compliance Technical Order
T/N	Tail Number
TOD	Tech Order Data
VVI	Vertical Velocity Indication

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 AND PURPOSE

a. Authority

On 22 Dec 2010, General Gary L. North, Commander, Pacific Air Forces (PACAF), in accordance with (IAW) Air Force Instruction (AFI) 51-503, appointed Brigadier General James S. Browne to conduct an aircraft accident investigation of a mishap that occurred on 16 Nov 2010 involving an F-22A Raptor aircraft, tail number (T/N) 06-4125, at Joint Base Elmendorf-Richardson (JBER), Alaska (AK). The investigation was conducted at JBER, from 4 Jan 2011 through 14 Jan 2011, 3 Jun 2011 through 13 Jun 2011, and 11 Jul 2011 through 21 Jul 2011. Board members were [AIB Pilot Member], [AIB Maintenance Officer Member], [Original AIB Legal Advisor], [AIB Medical Advisor], [AIB Human Factor Advisor], [AIB Maintenance Enlisted Member], and [AIB Recorder]. (Tab Y-3 through Tab Y-9) On 10 Feb 2011, General North, appointed [New AIB Legal Advisor] as substitute Legal Advisor for [Original AIB Legal Advisor]. (Tab Y-10)

b. Purpose

This is a legal investigation convened to inquire into the facts surrounding the aircraft or aerospace accident, to prepare a publicly-releasable report, and to gather and preserve all available evidence for use in litigation, claims, disciplinary actions, administrative proceedings, and for other purposes.

2. ACCIDENT SUMMARY

At 18:17 hours local time (L), 16 Nov 2010, the mishap pilot (MP), Capt Jeffrey Haney, flying F-22A, T/N 06-4125, the mishap aircraft (MA), departed JBER as number 3 of a 3-ship formation for an opposed surface attack tactics (SAT) training mission. The weather in the area was clear with unlimited visibility and 74% moon illumination over snow covered terrain. The tactical mission portion of the flight was completed uneventfully. At 19:39:57L, during the return-to-base (RTB) portion of the flight, data from the mishap flight lead's (MFL) intra-flight data link (IFDL) showed the MA in front of the MFL bearing 131 degrees at 13 nautical miles (NM), heading 183 degrees, 1,039 knots true airspeed (KTAS) at 38,400 feet (ft) above mean sea level (MSL). At some time after that, the MFL directed the MP to rejoin. According to the recovered crash survivable memory unit (CSMU), at 19:40:44L the MA entered a climbing right turn to commence the rejoin. At 19:42:18L a C BLEED HOT caution integrated caution, advisory, and warning (ICAW) asserted. The MP began a descent and retarded the throttles to IDLE power. At 19:42:53L, the MA entered a 240 degree roll through inverted, and the nose down (ND) pitch attitude increased. At 19:43:24L the MP initiated a dive recovery. Approximately three seconds later, the aircraft impacted the ground 48 degrees ND at a speed greater than 1.1 Mach (M) and was destroyed. A damage cost of $147,672,000.00 includes the

total destruction of the MA along with its internal stores. The MP did not eject and was fatally injured.

3. BACKGROUND

The MA belonged to the 3rd Wing (3WG) at JBER. It was operated by the 525th Fighter Squadron (FS). The MA took off from the JBER airfield and impacted approximately 120 NM north of the base.

a. Pacific Air Forces

Pacific Air Forces' (PACAF) primary mission is to provide ready air and space power to promote US interests in the Asia-Pacific region during peacetime, through crisis and war. The command's vision is to be the most respected air warrior team employing the full spectrum of air and space power, with our Asia-Pacific partners, to ensure peace and advance freedom. PACAF's area of responsibility extends from the west coast of the United States to the east coast of Africa and from the Arctic to the Antarctic, more than 100 million square miles. The area is home to nearly two billion people who live in 44 countries. PACAF maintains a forward presence to help ensure stability in the region. (Tab DD-3)

b. Unit Information

(1) 11th Air Force, Joint Base Elmendorf-Richardson, Alaska

The 11th Air Force (11AF) plans, conducts, controls and coordinates air operations IAW the tasks assigned by the PACAF commander, and is the force provider for Alaskan Command, the Alaskan Aerospace Defense Command Region, and other unified commands. Its units provide a network of critical air surveillance and command, control and communications functions necessary to perform tactical warning and attack assessment in defense of Alaska. (Tab DD-5)

(2) 3rd Wing, Joint Base Elmendorf-Richardson, Alaska

The 3WG trains and equips an Air Expeditionary Force lead wing comprised of more than 2,400 Airmen and F 22A, E-3B, C-17, C-12, and C-130 aircraft. It is located on JBER in Anchorage, AK. Its mission is to support and defend U.S. interests in the Asia Pacific region and around the world by providing units who are ready for worldwide air power projection and a base that is capable of meeting the Pacific Command's theater staging and throughput requirements. (Tab DD-9)

(3) 525th Fighter Squadron

The 525th Fighter Squadron (525FS) is a combat-ready fighter squadron prepared for rapid worldwide deployment. Flying the AF's premier aircraft, the F-22A Raptor, the 525th provides air dominance for the United States and its allies.

The 525FS originally activated as the 309th Bombardment Squadron (Light) on 10 Feb 1942. The 525th Tactical Fighter Squadron inactivated on 1 Apr 1992. After 15 years of inactivation, PACAF redesignated and activated the 525FS at Elmendorf Air Force Base, AK, on 29 Oct 2007. The 525FS is now armed with the Air Force's premier fighter aircraft -- the F-22A Raptor.

Currently, the squadron trains in the fighter missions of offensive and defensive counter air (air-to-air), as well as strategic attack and offensive counter attack (air-to-surface). (Tab DD-11)

c. F-22A Raptor

The F-22A Raptor is a single seat, multi-role fighter aircraft. Its combination of stealth, supercruise, maneuverability, and integrated avionics represents an exponential leap in warfighting capabilities and make it the world's most advanced fighter. The Raptor performs both air-to-air and air-to-ground missions allowing it to project air dominance and defeat threats attempting to deny access to our nation's Air Force, Army, Navy and Marine Corps. This capability provides a critical edge to joint force commanders and acts as an effective deterrent to future adversaries. (Tab DD-15)

4. SEQUENCE OF EVENTS

a. Mission

The mishap sortie (MS) was scheduled and briefed as a night opposed SAT mission with aerial refueling. The mission involved six F-22As with callsigns Jake 01 through 03 and Rocky 01 through 03. These six were joined by four F-16s from Eielson AFB, callsigns Mig 01 through 04. The pilot of Rocky 01 was the MFL and the pilot of Rocky 03 was the MP. Originally, the F-22As were to proceed to a tanker, conduct aerial refueling, fight an opposed SAT mission, aerial refuel once more, and then conduct an additional unopposed SAT mission. Due to a delay in the takeoff time for high winds at JBER, the F-22As only refueled a single time after they executed their first SAT mission. (Tab R-4, R-60 through R-61)

Jake and Rocky flights took off 10 minutes apart and operated as two separate flights of friendly forces (Blue Air) fighting Mig flight acting as enemy forces (Red Air). Opposed SAT missions

typically consist of F-22As fighting their way into a target area protected by enemy forces and dropping Joint Direct Attack Munitions (JDAM) on specified targets. The purpose of this mission was a night flight lead (FL) upgrade mission for Jake 01 with Jake 03 as his qualified instructor pilot (IP) and a night continuity training sortie for Rocky 01 through 03. (Tab R-4 through R-5, R-60 through R-61, Tab K-10)

The mishap mission was flown in Dice and Paxson Airspace scheduled by 3WG for these training purposes. Dice and Paxson are over land designated military operating areas (MOAs) north of JBER. The 525FS Director of Operations properly authorized the mission. (Tab K-5, K-9)

b. Planning

Jake 01 planned and briefed the mission as a SAT FL upgrade sortie in accordance with 3WG Administrative Standards, F-22A In-Flight Guide Supplement, and applicable Tactics, Techniques and Procedures. All Jake flight and Rocky flight members attended the entire brief at 15:15L, including the 525FS commander who was the IP of record for the upgrade sortie. The flight briefing covered all administrative flight information, weather, Notices to Airmen (NOTAMS), training rules, Special Interest Items, tanker operations, deconfliction between the two F-22A flights, and all items necessary to safely conduct the planned SAT training mission. Additionally, extra emphasis was placed on night operations and the use of night vision goggles (NVGs). (Tab K-10, K-13 through K-16, Tab R-53)

c. Preflight

In accordance with 3WG Administrative Standards, all flight members focused their NVGs prior to the brief in order to prepare for the night mission. All six pilots arrived at the operations desk at 16:35L for a final update briefing on weather, NOTAMS and other pertinent safety-of-flight information prior to going to their aircraft. Pilots were delayed approximately 20 minutes due to crosswinds at JBER. After the winds were within limits, the operations supervisor ("Top 3") gave the pilots their final update briefing. (Tab R-84 through R-85) This was the first mission of the season where Category III (cold weather gear) winter clothing was required based on the low temperature in the airspace. (Tab R-84, H-50 through H-55) Additionally, the pilots used Operational Risk Management (ORM) to evaluate mission risk. ORM is a decision-making process to systematically evaluate possible courses of action, identify risks and benefits, and determine the best course of action for any given situation. The ORM category for the mission was in the "High" range based on night operations, the changes to the mission due to a delayed takeoff for winds, and the fact that the MS was the MP's second event of the day. The MP's first event of the day was acting as the supervisor of flying (SOF). (Tab K-17) The Top 3 and the squadron commander made the decision to continue with the mission based on clear weather, diminishing winds, and minimal changes to the mission. (Tab R-84)

The pilots went to life support, donned the appropriate winter clothing and flight gear, and proceeded to their aircraft. The MP accomplished pre-flight inspections IAW 1F-22A-1 and 1F-22A-34 checklists. Ground and taxi operations were uneventful. (Tab R-85)

d. Summary of Accident

Jake flight took off at 18:05L; Rocky flight departed 10 minutes later. (Tab K-5) Departure and entrance into the Dice MOA was uneventful, and the weather in the airspace was clear with high moon illumination. (Tab F-3) As Rocky flight entered the airspace, Jake flight completed their first mission and proceeded to the KC-135 air refueling tanker as briefed. After refueling, Jake flight returned to the airspace, executed their second opposed SAT mission, and returned to JBER. (Tab R-46)

Rocky flight's first opposed SAT mission against Mig flight was uneventful. Rocky 02 reached a previously briefed fuel quantity prior to the MFL and MP, and proceeded to the tanker as a single aircraft. The MFL and MP followed Rocky 02 to the tanker to refuel. While on the tanker, Rocky 02 was troubleshooting minor, non safety-of-flight related avionics issues. The MFL directed Rocky 02 to return to Dice MOA to continue troubleshooting. Once the issues were resolved, the MFL directed Rocky 02 to fly an unopposed SAT mission as a single aircraft and RTB. (Tab R-5)

After receiving fuel, the MFL and MP executed a second unopposed SAT mission. In accordance with the brief, the MFL directed the flight to execute a high-altitude/high-airspeed SAT profile, followed by a safe escape maneuver to the south. Upon completion of tactical maneuvering, the flight proceeded towards the airspace exit point to RTB. (Tab R-5 through R-6)

At 19:39:57L, the last recorded data from the MFL IFDL showed the MA 13 NM in front of the MFL bearing 131 degrees, heading 183 degrees, 1.6 M at 38,400 ft MSL. (Tab J-2)

The MFL then directed the MP to rejoin to a 2 NM trail formation. The MP acknowledged the MFL's directive to rejoin and made no further communications. The MP began a climbing right hand turn to rejoin. The MA climbed to a maximum altitude of 51,720 ft MSL, crossed the MFL's projected flight path and then began a descent to the north. (Tab EE)

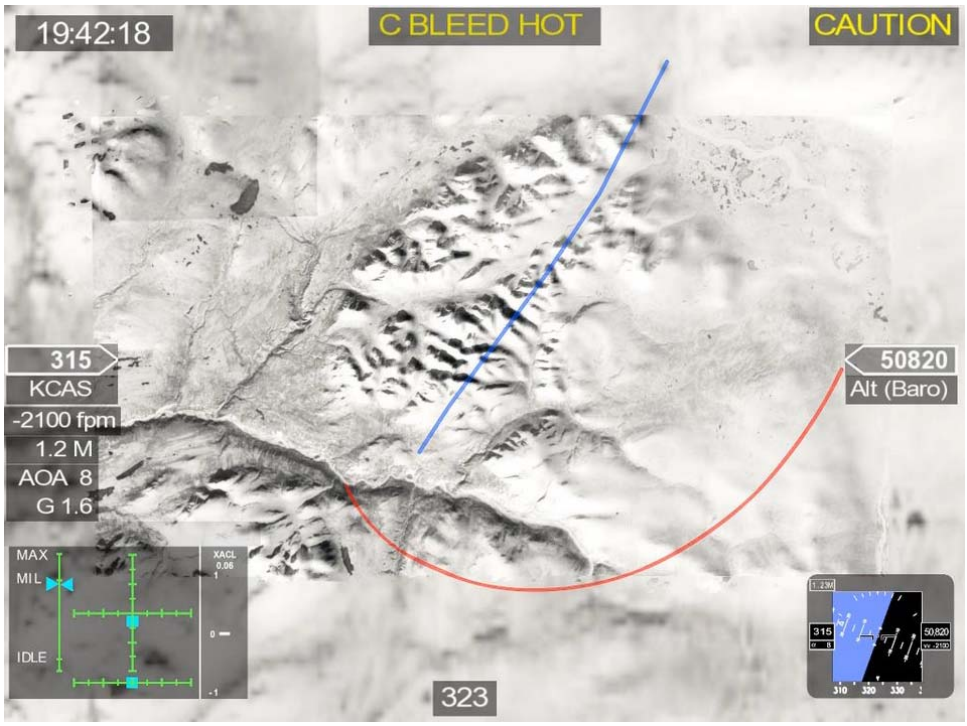

Figure 1 19:42:18L -- Relative position between MFL (blue) and MP (red) at the assertion of the C BLEED HOT caution ICAW. (Tab EE)

At 19:42:18L the fire protection system (FPS) detected a bleed air leak in the center bleed air ducting from both engines. In response to the FPS, the Integrated Vehicle Subsystem Controller (IVSC) asserted the C BLEED HOT caution ICAW while it requested the Environment Control System (ECS) to isolate the center bleed system. "CAUT" was displayed in the heads up display (HUD) advising the MP of the caution ICAW. (Tab J-4) When the C BLEED HOT caution ICAW asserted, the following functions were lost:

1) ECS
2) Air Cycle System (ACS) forced air cooling
3) On-board oxygen generating system (OBOGS)
4) On-board inert gas generating system (OBIGGS)
5) Cabin pressure

(Tab J-223)

The MA was at 50,870 ft MSL, 315 knots calibrated airspeed (KCAS), 1.23 M, with an attitude of 1 degree nose up, 69 degrees right wing down (RWD), heading 323 degrees, 1.5 g, and with a vertical velocity indication (VVI) of -1,700 ft per minute (fpm). (Tab EE)

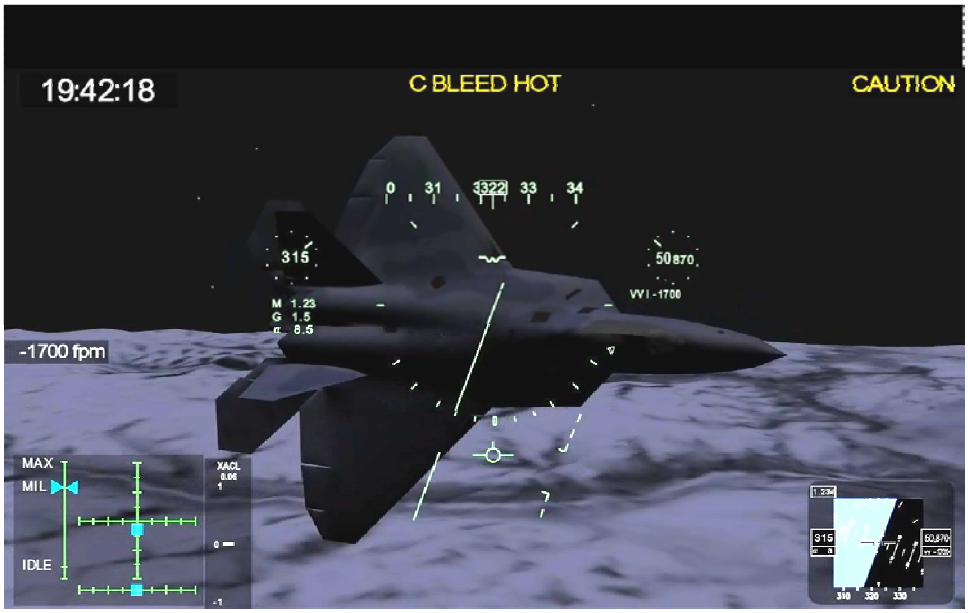

Figure 2 19:42:18 -- MA parameters at assertion of C BLEED HOT caution ICAW. (Tab EE) See Tab Z-10 for a diagram explaining the symbology in the Figures.

The C BLEED HOT caution ICAW cleared at 19:42:21L indicating the overtemperature condition no longer existed after the IVSC commanded the bleed air ducts to the closed position and stopped the flow of bleed air to the ECS. Due to the ECS no longer supplying pressure to OBOGS, the pressure dropped below the 10 pounds per square inch (psi) minimum threshold and displayed an OBOGS FAIL caution ICAW at 19:42:23L. (Tab J-12 and J-23)

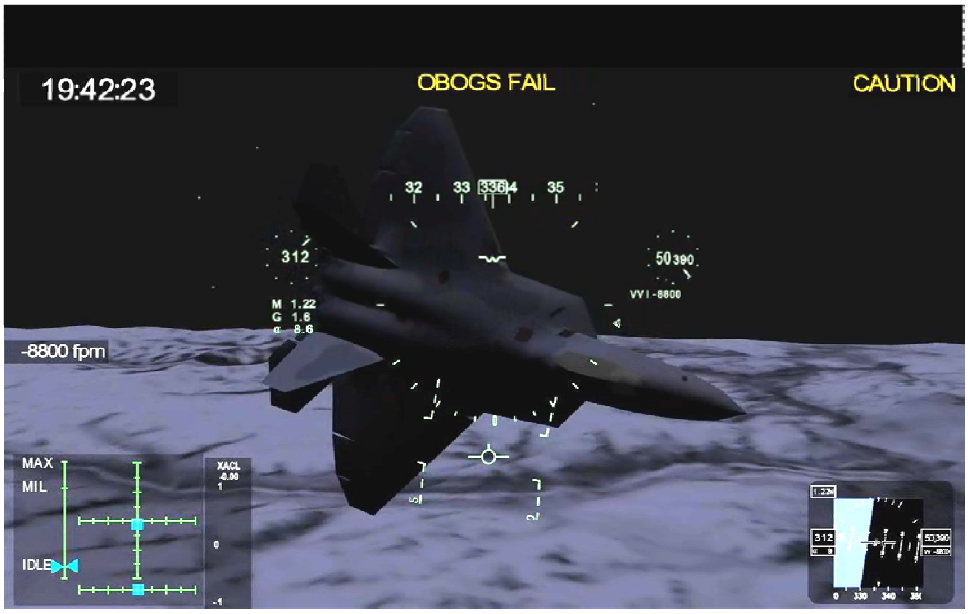

Figure 3 19:42:23 – MA parameters at assertion of OBOGS FAIL caution ICAW. (Tab EE)

At the assertion of this ICAW until 19:42:45L, the MP retarded the throttles to IDLE power and deliberately continued a controlled, descending right hand turn to descend to a lower altitude IAW the checklist. (Tab BB-29) At this time the MA was at 41,460 ft MSL, 390 KCAS, 1.29M, 30 degrees ND, 44 degrees RWD, 1.7 g, and with a VVI of -33,700 fpm. (Tab EE)

Figure 4 19:42:45 – MP deliberately flew to a controlled attitude of 30 degrees ND and 44 degrees RWD in order to descend to a lower altitude IAW the checklist. (Tab EE)

The CSMU mishap data discrete signal showed partial pressure to the MP's oxygen mask stopped shortly after 19:42:37L, which would lead to severely restricted breathing. (Tab J-43) From 19:42:45L until 19:42:53L, the MP made no inputs to the stick, pedals, or throttles, and the MA maintained a relatively stable bank angle and attitude. The MA was at 37,110 ft MSL, 470 KCAS, 1.35M, 30 degrees ND, 46 degrees RWD, 0.8 g, with a VVI of -37,700 fpm. (Tab EE)

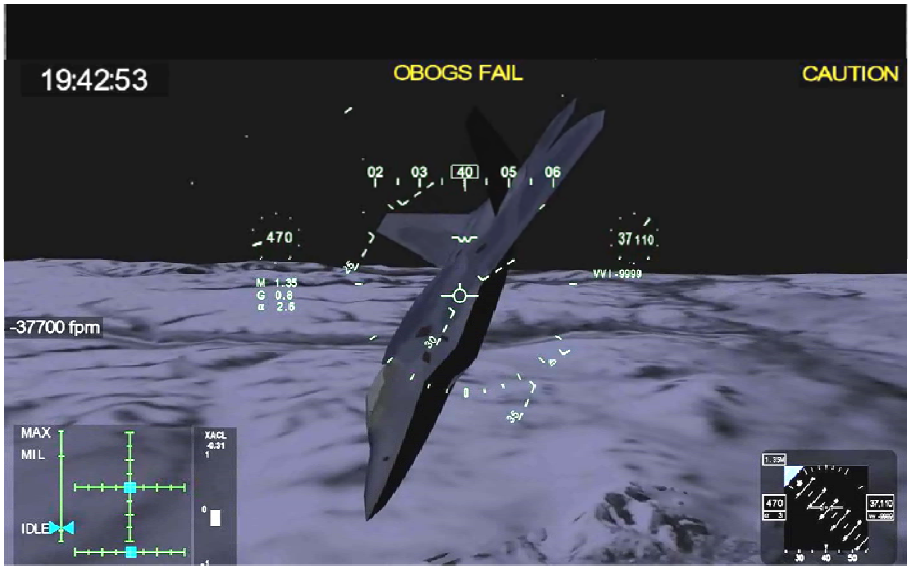

Figure 5 19:42:53 – MA parameters after 8 seconds of zero MP inputs to stick, pedals, or throttles. (Tab EE)

At 19:42:53L, the MP input a combination of right forward stick and right pedal which initiated a 240 degree descending right roll at greater than 45 degrees per second. (Tab EE)

Figure 6 19:42:57 – MA parameters during MA 240 degree roll to the right resulting from stick and pedal inputs. (Tab EE)

At the completion of these stick and pedal inputs at 19:43:08L, the MA had rolled through inverted, experienced less than 1 g of gravitational force, and went from a RWD to Left Wing Down (LWD) attitude, and the descent rate of the aircraft significantly increased. The parameters at this time were 24,070 ft MSL, 627 KCAS, 1.39M, 44 degrees ND, 81 degrees LWD, 0.8 g, with a VVI of -57,800 fpm. (Tab EE)

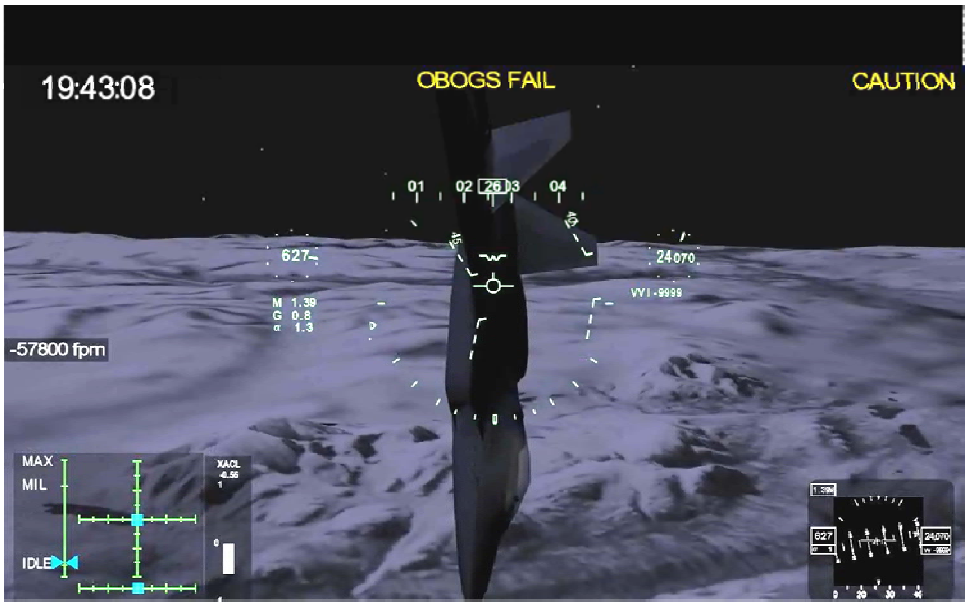

Figure 7 19:43:08 – MA parameters when stick and pedal inputs cease after the 240 degree roll. (Tab EE)

After 19:43:08L, there were no stick inputs and only very minor pedal inputs for the next 15 seconds. At 19:43:13L, passing approximately 19,000 ft MSL, a CABIN PRESSURE caution ICAW asserted based on cockpit pressurization exceeding its normal schedule. (Tab J-13)

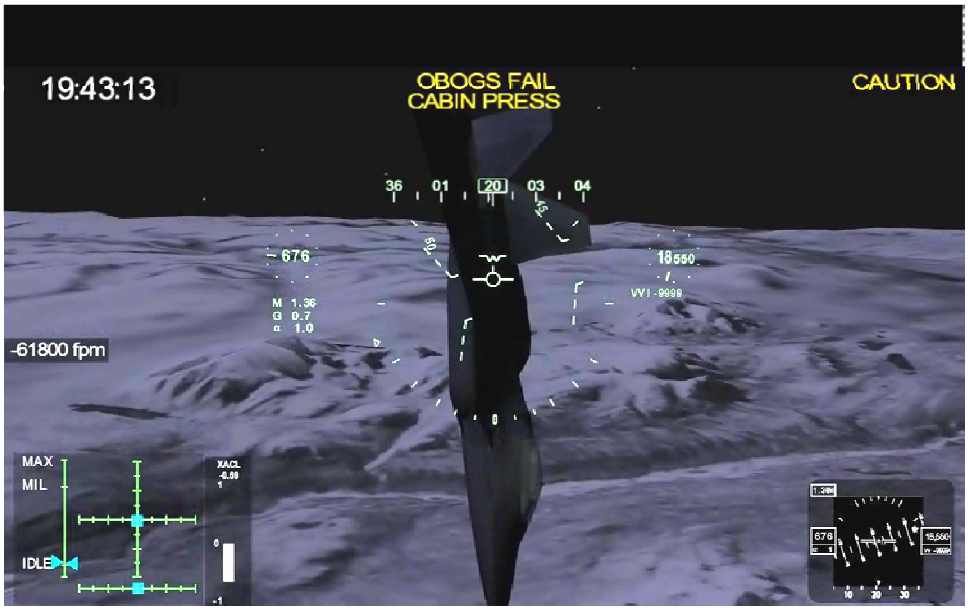

Figure 8 19:43:13 – MA parameters at assertion of CABIN PRESS caution ICAW. No stick or pedal inputs. (Tab EE)

At 19:43:18L, passing 12,400 ft MSL, an AIR COOLING caution ICAW asserted. This ICAW would assert 60 seconds after a C BLEED HOT caution ICAW if the aircraft were not receiving an adequate cooling air source to its avionics. (Tab J-13)

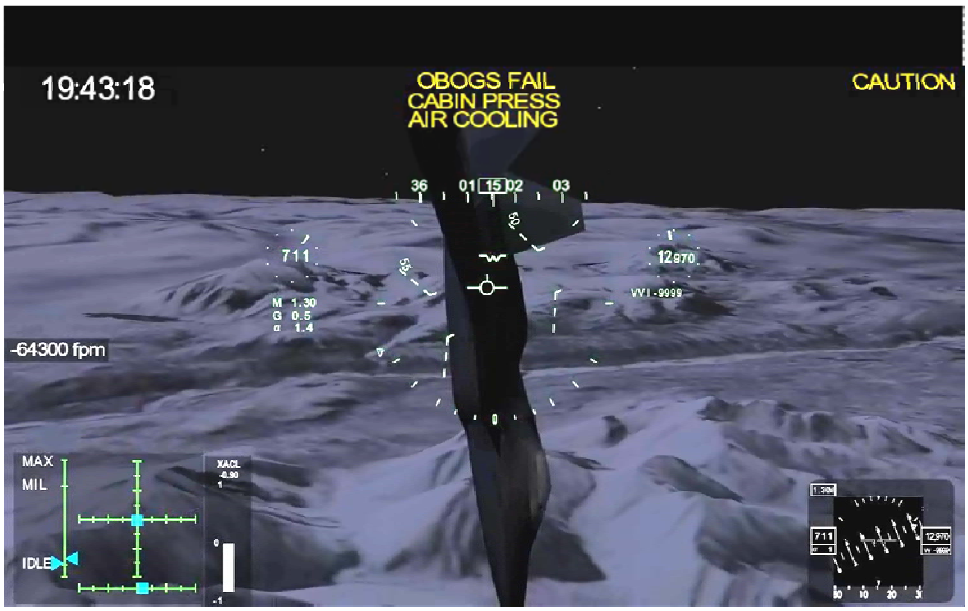

Figure 9 19:42:18 – MA parameters at assertion of AIR COOLING caution ICAW. No stick or pedal inputs. (Tab EE)

At 19:43:24L the MP performed a dive recovery at 5,470 ft MSL by pulling aft on the stick, producing a 7.4 g pull up maneuver. The MA impacted the ground 3 seconds later, inflicting fatal injuries to the MP and destroying the MA. (Tab EE)

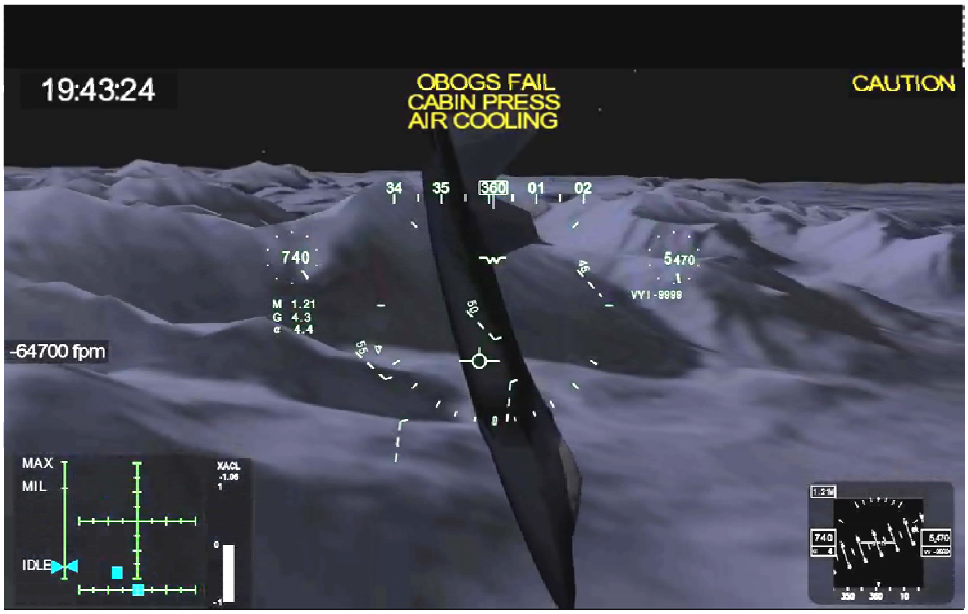

Figure 10 19:43:24 – MP initiates full aft stick pull to start dive recovery at 5,470 ft MSL. (Tab EE)

e. Impact

At 19:43:27L, the MA impacted the ground at 735 KCAS, 1.17M, 48 degrees ND, 47 degrees LWD, 7.4 g, with a VVI of -57,900 fpm. The impact site is approximately 120 NM north of JBER, AK, in the Talkeetna Mountain range. The site is approximately 3,100 ft MSL near the edge of a south-west to north-east running valley. The impact crater is located at the valley floor where it begins to slope upwards towards the southeast. The valley floor is approximately one-half mile wide at this point and has a stream running through it approximately 60 yards west of the impact point. (Tabs J-4 through J-6)

The debris field consisted of small aircraft and engine pieces extending approximately one-quarter mile from the crater. The upslope wall of the crater and aircraft impact angle appear to have focused the debris pattern in a 60 – 80 degree wide arc from west to north. (Tabs J-4 through J-6)

Figure 11 Impact Crater 17 Nov 2010 (Tab S-7)

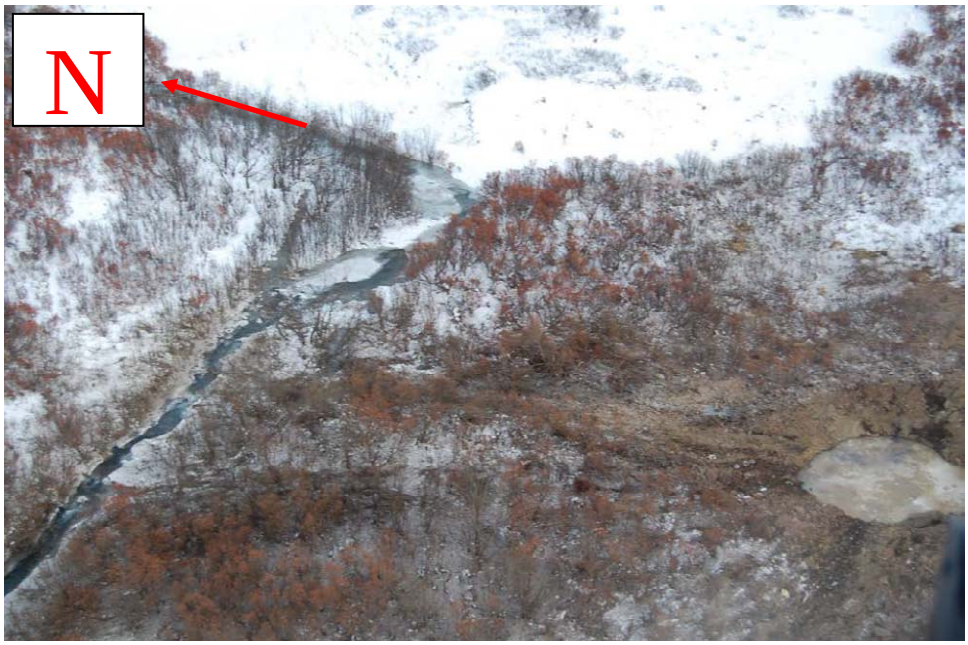

Figure 12 Impact Site. 17 Nov 2010 (Tab S-7)

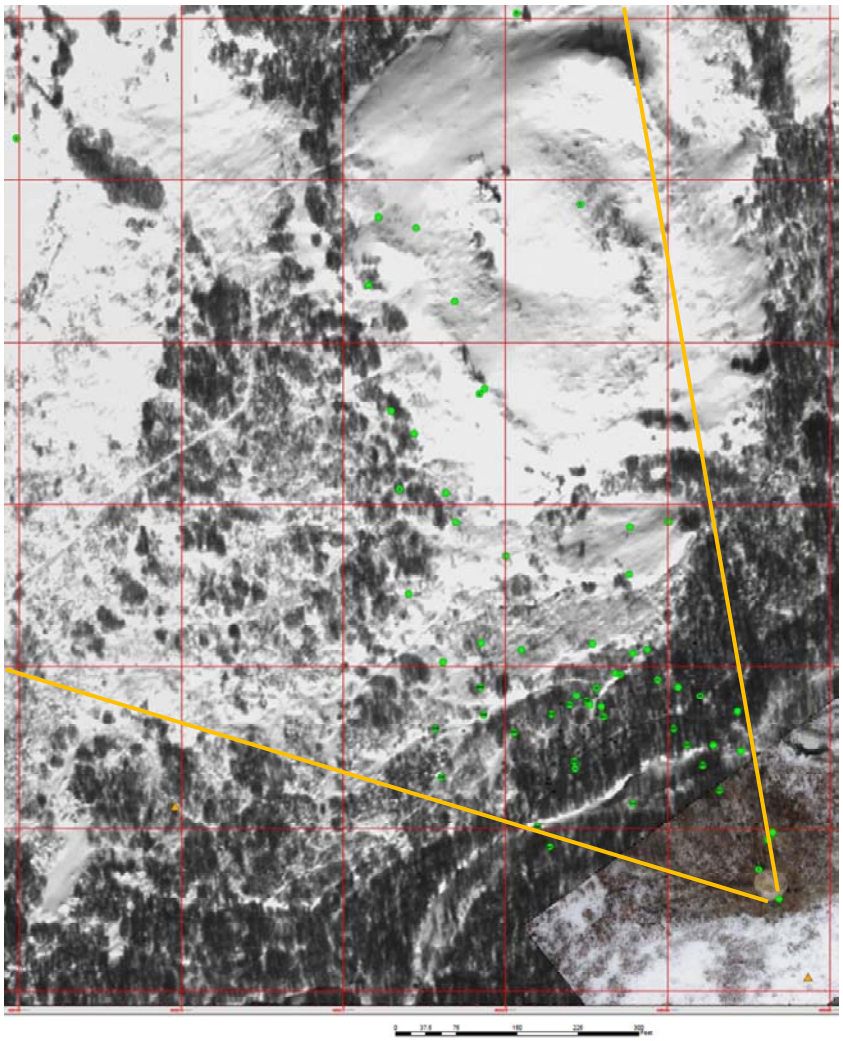

Figure 13 Aircraft Parts Scatter Diagram. Parts represented by green dots. (Tab S-4)

f. Egress and Aircrew Flight Equipment (AFE)

All life support equipment onboard the MA had current inspection dates and were deemed serviceable by 3 Operational Support Squadron (3OSS) AFE members. (Tab H-17 through H-23) The MP had two repairs performed on his advanced tactical anti-g system (ATAGS) on both the preceding day and the day of the mishap. All repairs, modifications, testing, and fittings were performed by qualified AFE members IAW all applicable technical orders (TO). (Tab R-117 through R-121)

Based on analysis of the escape system and life support equipment located in the debris field, an ejection did not occur and therefore, there was no opportunity for the MP to use survival gear or life support equipment. (Tab H-5 through H-9)

Additionally, based on forensic analysis of the right bayonet clip of the MP's helmet recovered in the debris field, it appears the MP had his oxygen mask on and secured at the time of impact. (TAB J 75, 76 and 98 through 105)

g. Search and Rescue (SAR)

At 20:10L on 16 Nov 2010, 11AF Rescue Coordination Center received notification of an overdue aircraft. Initial on scene and search and rescue efforts were conducted by the MFL, Alert F-22As, and a KC-135. Alaska Air National Guard HH-60s and HC-130s located the crash site the following morning. SAR team analysis of the crash site determined that the MP did not eject from the aircraft. (Tab AA-4) Significant snowfall with sub-freezing temperatures began the following week, covering the aircraft wreckage and making location and identification of aircraft wreckage more difficult. (Tab J-5)

h. Recovery of Remains

JBER personnel were responsible for recovery operations. Crash, fire, rescue personnel, and civil engineers were pivotal to recovery efforts. Remains were recovered during the initial recovery beginning 17 Nov 2010 and additionally when the recovery team reconvened at the site in May 2011. The remains were transferred to the Air Force Institute of Pathology (AFIP) Mortuary Affairs. (TAB CC-15)

5. MAINTENANCE

a. Forms Documentation

The 3rd Maintenance Group, JBER, maintained the aircraft forms for the MA. The F-22A aircraft maintenance records are stored in an electronic management database referred to as the Integrated Maintenance Information System (IMIS). IMIS tracks all scheduled and unscheduled maintenance activities, repairs, aircraft flying hours, maintenance personnel activity, and Technical Order Data (TOD). A detailed 90-day maintenance records review in IMIS was completed. The historical aircraft forms revealed no major documentation errors. (Tab D-4, D-5, D-6)

b. Inspections

Time Compliance Technical Orders (TCTOs) are inspections or maintenance procedures required before specific dates or flight. No TCTOs restricted the MA from flying. Historical records located in IMIS showed all TCTO accomplishment IAW applicable guidance. There were no overdue component time changes or TCTOs. (Tab D-7, D-8, D-9)

The MA flew 31 flights totaling 44.3 hours within 90 days of the mishap. There were no major maintenance discrepancies that would have prevented the MA from accomplishing the training flight on 16 Nov 2010. Also, historical records did not reveal any recurring or repeating maintenance problems. (Tab D-5)

A Pre-Flight (PR) is a flight preparedness inspection performed prior to flight and is a valid inspection for 72 hours once completed. The PR inspection is governed by TO 00-20-1 and is performed in accordance with the F-22A PR inspection TO. The purpose of this inspection is to visually inspect and operationally validate various areas and systems of the aircraft in preparation for a flying period. The maintenance technician reported no discrepancies on PR performed on 15 Nov 2010 at 20:50L, approximately 21.5 hours prior to the incident. The PR did not contribute to the mishap. (Tab D-4, D-5)

c. Maintenance Procedures

The most recent major maintenance procedure performed on the MA was the Contract Field Team accomplishment of TCTO 1F-22A-1222 on 5 through 27 Oct 2010. The TCTO consisted of maintenance performed on both horizontal tail surfaces. All documentation was reviewed. The TCTO actions did not contribute to the mishap. (Tab U-4 through U-5)

A major maintenance inspection for the F-22A is the Packaged Maintenance Plan (PMP) concept. The PMP is scheduled maintenance tasks determined by airframe hours specified by TO 1F-22A-6. According to TO 1F-22A-6, the first PMP is due at the 900 airframe hour mark. The MA was not due for its first PMP for another 431 hours. The PMP did not contribute to the mishap. (Tab D-3)

d. Maintenance Personnel and Supervision

The 3rd Maintenance Group, JBER, maintained the MA. All pre-mission activities were normal and all personnel involved in the PR and launch of the MA were experienced and competent. A thorough review of maintenance training records in the electronic Training Business Area (AF Form 623s and AF Form 797s) revealed all involved personnel were properly trained and qualified. (Tab G-2)

e. Fuel, Hydraulic and Oil Inspection Analyses

The Fuels Laboratory from JBER and Eielson AFB sent fuel samples to the Air Force Petroleum Agency, Wright-Patterson AFB, OH, IAW TO 42B-1-1. The two R-11 refuel trucks from JBER and fuel samples taken from the KC-135 aircraft that refueled the MA were sent for testing. All fuel samples were within limits and were satisfactory for use. (Tab D-25 through D-41)

The following aircraft ground support equipment samples were taken: Polyalphaolefin (PAO), hydraulic, and oil cart. All samples were tested and found to be within limits and satisfactory for use. (Tab D-21 through D-25)

The impact destroyed both engine reservoirs, gearboxes, and other containers that held PAO, hydraulic, and oil fluid preventing post-impact sample retrieval.

f. Unscheduled Maintenance

Review of the maintenance records for MA indicates that both engines were replaced one week before the mishap by the 3rd Maintenance Group at JBER. The #1 engine (E0123) required

removal because the engine oil sample showed high iron during a routine oil analysis sample. The #2 engine (E0316) required removal to complete a heat exchanger time change replacement. The ECS bleed air duct disconnection and reconnection were performed during engine removal and installation tasks. A journeyman technician, a craftsman technician, and a Quality Assurance (QA) inspector performed engine bay inspections on both left and right sides with no defects noted. Following engine installations, a journeyman technician, a craftsman technician, and a QA inspector verified installation with no defects noted. Engine operational checks were accomplished with no maintenance issues reported. No other ECS maintenance was performed on the MA within the 90-day maintenance review. (Tab J-34) All maintenance actions were in order, appropriate, and did not contribute to the mishap.

6. AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS.

a. Structures and Systems

The high rate of speed at impact destroyed a majority of components from the aircraft. A thorough inspection of all recovered and identified aircraft parts was completed. Due to the extreme destruction of the aircraft and the engines, analysis was difficult. (Tab J-3)

(1) Crash Survivability Memory Unit

The recovered CSMU, manufactured by L3 Communications, was sent to Lockheed Martin Aeronautics Company (LM-Aero) for evaluation. LM-Aero was able to compile a chronological summary of significant events and aircraft system integrity using the CSMU data. (Tab L-3 through L-7, J-10)

(2) Flight Control System (FLCS)

The CSMU mishap data indicated normal operation of the FLCS. The Initiated Built-In Test passed prior to flight, and no other fault report codes (FRC) were reported in the mishap CSMU file. (Tab J-14)

(3) Electrical Power System (EPS)

The CSMU mishap data indicated normal operation of the EPS. There were no EPS failures throughout the flight. (Tab J-20)

(4) Auxiliary Power Generating System (APGS)

The APGS, via the auxiliary power unit (APU) provides bleed air for use by the ECS and for airframe-mounted accessory drive (AMAD) motoring. Upon review of the CSMU data, the APGS was functioning normally. (TAB J-20)

(5) Engines

The CSMU mishap data indicated both engines responded to pilot input and operated normally throughout the flight envelope. Both engines were Pratt and Whitney (P&W) F119-PW-100 turbofan engines. The #1 engine (PW0E730305) had 595.5 hours. The #2 engine (PW0E70296) had 685.4 hours. There were no overdue inspections or time changes on either engine. (TAB D-1, D-2, J-30)

(6) Hydraulic Power System

The CSMU mishap data indicated normal operation of the hydraulic power system. (TAB J-30)

(7) Fuel System

Review of the CSMU mishap data revealed normal fuel system performance as designed during normal flight operations and emergency operations. (TAB J-30)

(8) Environmental Control System

When the ECS system IVSC logic detected a manifold bleed air leak, a C BLEED HOT caution ICAW asserted. In this case, the logic commanded all bleed air regulating shutoff valves to close. This action protects against a bleed air induced aircraft fire. Closing all the valves results in the immediate loss of all ECS bleed and conditioned air flow, removing air flow to the OBOGS unit. The air bleed valves will remain closed for the duration of the flight, even if the caution ICAW clears. (TAB J-24) Due to the extensive damage and limited evidence recovered, the cause of the bleed air leak could not be determined. Review of the MA wreckage and CSMU data revealed the ECS performed as designed throughout the flight.

(9) Escape System

The CSMU data showed that the canopy was down and the seat armed for the entire mishap flight. Physical evidence of the recovered components concluded the canopy was in the down and locked position and the ejection sequence was not initiated prior to impact. (TAB H-3)

(10) Integrated Vehicle Subsystem Controller

The IVSC provides control and/or monitoring of all aircraft utilities and subsystems in a centralized computer system. The following is an analysis of the IVSC fault data. Both the mishap and APU Time History (AT file) data were used for this analysis. The mishap data contained three Global Manager reported faults:

1. 4622 19 073 – Data Transfer/Mass Memory Video Recorder Not Responding on the Avionics System 1553 Bus ‘B’
2. 4622 04 076 – ECS Air Cooled Avionics Manifold Delta Pressure
3. 4622 04 331 – ECS Warm Air Manifold Delta Pressure

These faults did not contribute to the mishap. All IVSC assemblies appear to have been fully operational throughout the MS and did not contribute to the mishap. (TAB J-19)

b. Evaluation and Analysis

(1) Emergency Oxygen System

Analysis was conducted to determine if the EOS achieved activation and if the MP's oxygen mask was secured at the time of ground impact. Various components from the ECS, EOS, OBOGS, and a portion of the MP's helmet that included one bayonet receiver were submitted to the Air Force Research Laboratory Materials Integrity Branch (AFRL/RXSA) for evaluation. Based on the report findings the EOS did not activate and the MP's oxygen mask bayonet was up and secured in place at the time of ground impact. (TAB J-71 through 74) Due to the severe break-up of the MA, the following items were not recovered and therefore not available for analysis: left side bayonet, MP's oxygen mask, and ejection seat EOS assembly.

(2) Canopy Seal/Anti-G suit Air Regulating Valve

The canopy seal/anti G suit regulating valve is manufactured by Honeywell Aerospace and was analyzed by a Honeywell Aerospace investigator. This analysis was conducted to determine if the canopy seal and anti-G suit air regulating valve were properly functioning prior to impact. Due to bleed air pressure loss caused by the C BLEED HOT caution ICAW, the valve remained open as designed. The valve did not contribute to the mishap. (Tab D-5)

(3) On Board Oxygen Generation System

Honeywell Aerospace manufactures the OBOGS unit. The unit was evaluated by the Human System Department, Naval Warfare Center, Patuxent River, MD. The purpose of the evaluation was to assess a possible contamination of the OBOGS unit. The OBOGS analysis showed evidence of carbon dioxide that was determined to be medically insignificant. (Tab D-5, CC-13) Additionally, the canister test included detection of JP-5, JP-8 and PAO. JP-8 jet fuel detected in the sample was considered to be high; however, the canister was found opened and exposed to the environment during the recovery operations. Therefore secondary contamination was likely. Contamination of the oxygen system did not contribute to the mishap. (Tab J-60 through 66)

(4) Gas Chromatograph Analysis

Forensic swab collection was performed on the CRU-94, Breathing Regulator/Anti-G (BRAG) valve, canopy seal/anti-G suit air regulating valve, anti-g suit connector, O2 bulkhead fitting, OBOGS connector fitting, and OBOGS pressure regulator. These samples were analyzed by the University of Dayton. The BRAG valve dry swab contained the presence of materials that are components of jet fuel. The BRAG valve recovery location and exposure to the environment upon impact caused secondary contamination. (TAB J-137 through 146, CC-13) All other components tested were determined to have medically insignificant contaminants. (Tab CC-13) Therefore, contamination did not contribute to the mishap.

7. WEATHER

a. Forecast Weather

The weather forecast for JBER on 16 Nov 2010 predicted a scattered cloud layer at 7,000 ft above ground level (AGL), unlimited visibility, winds at 360 degrees at 12 knots gusting to 18 knots, light turbulence from surface to 3,000 ft, and a minimum altimeter setting of 30.23 inches of mercury. There was a temporary forecast until 18:00L for winds to be 010 degrees at 15 knots gusting up to 18 knots and decreasing to 12 knots at 20:00L. (Tab F-14) Additionally, there were weather warnings for wind gusts at 35 knots but less than 50 knots, and wind shear at 1,500 ft at 040 degrees at 44 knots until 18:00L. (Tab F-3)

The weather forecast in the Dice MOA predicted scattered clouds at 5,000 ft and 10,000 ft AGL, 7 statute miles of visibility, winds at 40,000 feet out of the north at 50 knots, and the contrail level from 25,000 to 39,000 ft. The moonrise was at 14:34L, and the illumination was 74%. (Tab F-3)

b. Observed Weather

The sorties earlier that day were canceled due to crosswinds out of limits, and the night sorties were delayed by 20 minutes until the winds were within limits. (Tab R-83 through R-85) The observed weather at JBER at takeoff time was as follows: winds at 030 degrees at 17 knots gusting up to 21 knots, 10 miles of visibility, clear skies, and a minimum altimeter setting of 30.42 inches of mercury. (Tab F-5) From pilot testimonies, there was no adverse weather in the airspace with clear skies, good illumination, and "one of the nicest" nights of the winter. (Tab R-45 through R-46)

c. Space Environment

Not applicable.

d. Operations

Weather did not affect operations and was not contributory to the mishap.

8. CREW QUALIFICATIONS

a. Mishap Pilot

The MP was a current and qualified IP and mission commander (MC) with 303.5 hours in the F-22A, 98.1 hours as an IP, and 812.4 total hours in fighter aircraft. Prior to his assignment to the F-22A, the MP accumulated 508.9 hours as a FL in the F-15C. The MP had 31.4 NVG hours in the F-22A, 41.7 total NVG hours, and 47.6 total night hours. (Tab G-3, G-10 through G-12)

The MP was recognized throughout his career for exceptional performance. He received numerous accolades and awards including: Distinguished Graduate, AETC Commanders Trophy winner, and Flying Excellence Award winner from Undergraduate Pilot Training; Top Overall Graduate and Distinguished Graduate from F-15C Fighter Training; and most recently, 525FS Flight Lead of the Year, Warrior of the Year, Turkey Shoot Top Flight Lead, Instructor Pilot of the Quarter, and selection as an alternate to the F-22A Weapons Instructor Course. (Tab T-3) He was regarded as one of the top pilots in the squadron among his peers and supervision. (Tab V-8.5 through V-8.6)

The MP flew four sorties in the two weeks prior to the mishap (Tab G-10), two of which were night missions with NVGs. The MP flew on 15 Nov 2010, the night prior to the mishap.

The MP's flight time and sortie count during the 90 days before the mishap are as follows:

	Hours	Sorties
Last 30 Days	8.1	5
Last 60 Days	18.6	13
Last 90 Days	29.7	21

(Tab G-56 through G-57)

MP qualifications were not contributory to this mishap.

b. Mishap Flight Lead

At the time of the mishap, the MFL was a current and qualified FL and MC with 272.8 hours in the F-22A, and 880.7 total hours in fighter aircraft. Prior to his assignment to the F-22A, the MFL accumulated 607.9 hours in the F-15C. The MFL has 18.4 NVG hours in the F-22A, 57.4 total NVG hours, and 69.2 total night hours. (Tab G-3, G-30 through G-31)

The MFL flew three sorties in the two weeks prior to the mishap, two of which were night missions with NVGs. The MFL flew on 15 Nov 2010, the night prior to the mishap. (Tab G-28)

The MFL's flight time and sortie count during the 90 days before the mishap are as follows:

	Hours	Sorties
Last 30 Days	7.7	4
Last 60 Days	16.2	11
Last 90 Days	27.6	20

(Tab G-56 through G-57)

MFL qualifications were not contributory to this mishap.

9. MEDICAL

a. Qualifications - Mishap Pilot

A review of the MP's medical record showed he was medically qualified for flight and worldwide duty. His most recent annual flight physical and Periodic Health Assessment were both performed on 23 Nov 2009. No waivers were identified. (Tab X-3)

b. Health

Medical records and individual history revealed the MP was in good health. After thoroughly reviewing the material described above, there was no evidence that any preexisting medical condition contributed to this mishap. (Tab X-3)

c. Pathology

The partial remains of the MP were recovered and positively identified. Injuries sustained by the MP were consistent with the nature of the mishap. The MP died instantly upon impact. (Tab X-3)

Toxicology testing was performed on the MP, FL, 2 Life Support and 69 ground support personnel. Samples were submitted to the AFIP for analysis. All results were negative with the exception of one civilian and one active duty maintenance member who each tested positive for a single substance. Further investigation revealed both individuals held valid prescriptions and appropriate diagnoses for the medication detected during testing. Drug use was not a factor in the mishap. (Tab X-3)

d. Lifestyle

No lifestyle factors were found to be relevant to the mishap.

e. Crew Rest and Crew Duty Time

All Air Force pilots are required to have "crew rest" IAW AFI 11-202, Vol. 3, prior to performing in-flight duties. AFI 11-202 states, in part, "Air Force aircrews require at least 10 hours of continuous restful activities including an opportunity for at least 8 hours of uninterrupted sleep during the 12 hours immediately prior to the FDP (Flight Duty Period) … The crew rest period is normally a minimum 12-hour non-duty period before the FDP begins. Its purpose is to ensure the aircrew member is adequately rested before performing flight or flight related duties. Crew rest is free time, which includes time for meals, transportation, and rest. Rest is defined as a condition that allows an individual the opportunity to sleep." (Tab BB-4)

There is no evidence to suggest inadequate crew rest was a factor in this mishap. (Tab R-139 through R-154)

10. OPERATIONS AND SUPERVISION

a. Operations

The 525FS did not have an elevated operations tempo in the month leading up to the mishap. The squadron had completed a Unit Compliance Inspection in Oct 2010 and was not scheduled to deploy until Jan 2011. All witnesses described the operations tempo as average and asserted that it did not negatively affect their ability to perform the mission. Operations tempo was not contributory to this mishap. (Tab V-8.5)

b. Supervision

The MS was flown as scheduled and planned with only minor deviations due to a delayed takeoff. The squadron commander was the IP of record for the MS and noted that all safety of flight items were covered thoroughly in the mission brief. (Tab R-53) Supervision was not contributory to this mishap.

11. HUMAN FACTORS

AFI 91-204, *Safety Investigations and Reports*, 24 September 2008, Attachment 5, contains the Department of Defense Human Factors Analysis and Classification System which lists potential human factors that can play a role in aircraft mishaps. (Tab BB-5) The following human factors were relevant to this mishap:

a. Causal

PC102 Channelized Attention

Channelized attention is a factor when the individual is focusing all conscious attention on a limited number of environmental cues to the exclusion of others of a subjectively equal or higher or more immediate priority, leading to an unsafe situation. This factor may be described as a tight focus of attention that leads to the exclusion of comprehensive situational information. (Tab BB-5)

In the F-22A Emergency Procedures OBOGS FAIL checklist, the pilot is to activate the EOS if he "is experiencing hypoxia or other physiological symptoms." Severely restricted breathing is a physiological symptom which would have prompted the MP to activate the EOS; however, post-mishap forensic analysis determined the EOS was not activated. (Tab J-76)

The MP displayed channelized attention when the OBOGS stopped airflow to the MP's oxygen mask and caused severe restrictive breathing. Based on the sequence of events, the fact that the EOS was never activated, and the fact the MP's oxygen mask was up and secured, it was most likely the MP channelized his attention on restoring airflow to his oxygen mask.

During the sequence of events, the pilot experienced a discernible 45 degree per second roll rate, a discernible linear acceleration change, and less than 1 g. (Tab EE) These forces were well above the minimally detectible thresholds and should have been recognized by the MP. (Tab CC-3) However, due to channelized attention, the MP appeared unaware of these discernible stimuli.

The MP's channelized attention caused a breakdown in his visual scan. This delayed recognition of the MA's attitude and thereby delayed the corrective actions necessary to recover the MA.

AE105 Breakdown in Visual Scan

Breakdown in visual scan is a factor when the individual fails to effectively execute learned/practiced internal or external visual scan patterns. The breakdown can lead to an unsafe situation. (Tab BB-5)

At 19:42:45L intentional flight control inputs stopped and did not resume for approximately 39 seconds. During this period, the MA performed a 240 degree right roll and increased to 53 degrees ND. (Tab EE) Had the MP continued to perform an effective visual scan, he would have recognized the unusual attitude of the MA and would have had adequate time to take corrective actions.

PC508 Spatial Disorientation (Type 1) Unrecognized

Spatial Disorientation is a failure to correctly sense a position, motion, or attitude of the aircraft or of oneself within the fixed coordinate system provided by the surface of the earth and the gravitational vertical. Spatial Disorientation (Type 1) Unrecognized is a factor when a person's cognitive awareness of one or more of the following varies from reality: attitude, position, velocity, direction of motion or acceleration. Proper control inputs are not made because the need is unknown. (Tab BB-5)

IAW the OBOGS FAIL checklist, the MP was in a deliberate and controlled descent to a lower altitude after the assertion of the OBOGS FAIL caution ICAW. However, at 19:42:53L the MP input stick and pedal movements for approximately 20-seconds, culminating in a 240 degree descending right roll. (Tab EE) At the completion of these stick and pedal inputs at time 19:43:08L, the MA had rolled through inverted, experienced less than 1 g of gravitational force, transitioned from a RWD to LWD attitude, and significantly increased the descent rate of the MA.

The fact that the MP went from a controlled flight regime to an unusual attitude and did not take corrective actions for 30 seconds suggests he had unrecognized spatial disorientation. At 19:43:24L the MP recognized the MA's position and attempted to perform a dive recovery by pulling aft on the stick, producing a 7.4 g pull up maneuver. The MA impacted the ground 3 seconds later, inflicting fatal injuries to the MP and destroying the MA.

b. Contributory

OP004 Organizational Training Issues/Programs

Organizational Training Issues/Programs are a factor when one-time or initial training programs, upgrade programs, transition programs or other training that is conducted outside the local unit is inadequate, unavailable, etc. creating an unsafe situation. Failure of an individual to absorb the training material in an adequate training program does not indicate a training program problem. (Tab BB-5)

USAF aircrew are highly trained to handle multiple and/or severe aircraft emergencies, but not with all forms of physiological duress. Additionally, the 525FS supervised emergency procedure training for the month of Nov 2010 included a review of the C BLEED HOT emergency procedures. Evidence showed the MP's oxygen mask was up and secured in place and the MP had not activated the EOS. Because of these factors, the MP most likely experienced a sense similar to suffocation. This was likely the MP's first experience under such physiological duress. The unique and added stress of the breathing restriction contributed to the MP's channelized attention and break down of visual scan that occurred on the night of the MS. This gap between aircrew training and real world physiological duress was contributory to this mishap.

PE207 Personal Equipment Interference

Personal Equipment Interference is a factor when the individual's personal equipment interferes with normal duties or safety. (Tab BB-5)

The MP was wearing CAT III cold weather gear and NVGs during the MS. (Tab H-53 through H-58) Ground simulation demonstrated reduced mobility in the cockpit due to the bulkiness of CAT III gear. Additionally, the NVGs hit the canopy, interfering with the pilot's ability to look from side to side and down at the consoles. In order to obtain head/canopy clearance, the pilot had to shift his torso by bracing himself on various areas in the cockpit. (Tab CC-5) These bracing actions and limited tactile sensation due to the CAT III gear demonstrated how inadvertent flight control inputs could occur.

PE204 Controls and Switches

Controls and Switches is a factor when the location, shape, size, design, reliability, lighting, or other aspect of a control or switch is inadequate and this leads to an unsafe situation. (Tab BB-5)

The lack of airflow to the MP's oxygen mask and the fact that the mask was up and secured in place at the time of impact suggests the MP would have attempted to activate the EOS for continued airflow. However, analysis of the EOS from the wreckage determined it was not activated.

1F-22A-1 states: "To manually activate the EOS, pull the green ring up and out of the retaining slot (approximately 33 pound pull), then pull directly forward minimizing inboard/outboard and upward motion. The pull force required to activate the EOS may be in excess of 40 lbs. The green ring will travel approximately two inches and will not release from the seat side. There is no obvious detent to indicate that the EOS has been activated." (Tab BB-17)

The AFRL report identified that if the EOS wedge block had been incorrectly installed, the wedge block would be unable to move or rotate during manual EOS ring activation. However, during ground simulation the board members were able to initiate the EOS in the incorrectly installed position. (Tab U-4)

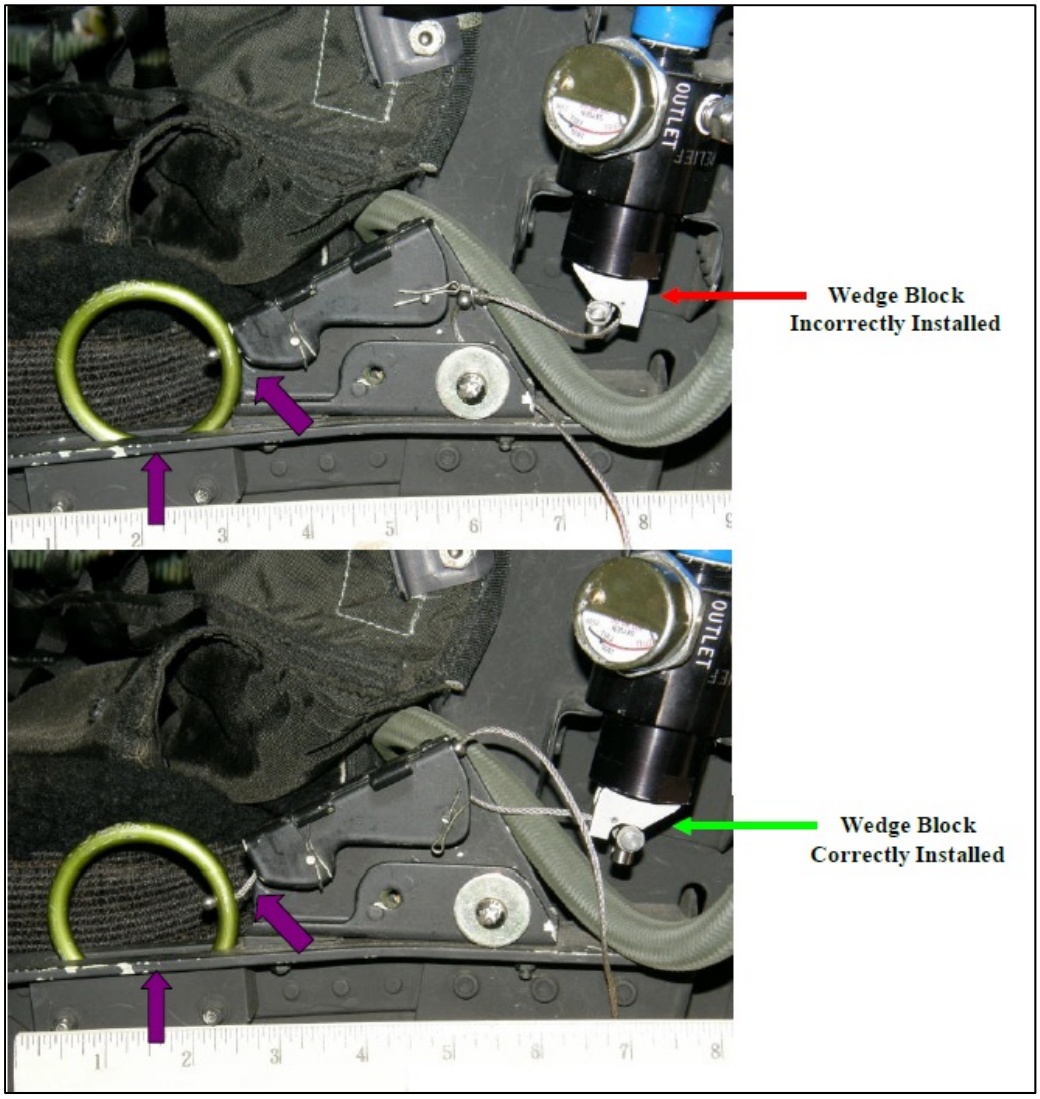

Figure 14- The wedge block installed incorrectly (red arrow) and correctly (green arrow). Notice the position of the ring within the seat (purple arrows) based on wedge block position. (Tab Z-6)

During ground simulation, the manual EOS activation ring was unseated and dropped between the seat and console prior to EOS activation. This was done to simulate a failed initial pull,

which may have occurred for various reasons, including: the EOS activation ring was dropped or the EOS cable jammed during an attempted manual activation. Retrieval of the ring from between the seat and console would be difficult based on the seat position, night environment, and with personal equipment interference (as discussed in the next section). (Tab CC-5)

Figure 15 - Pilot pulling EOS activation ring. NVG interfering with EOS ring visualization. (Tab CC-5 and Tab Z-7)

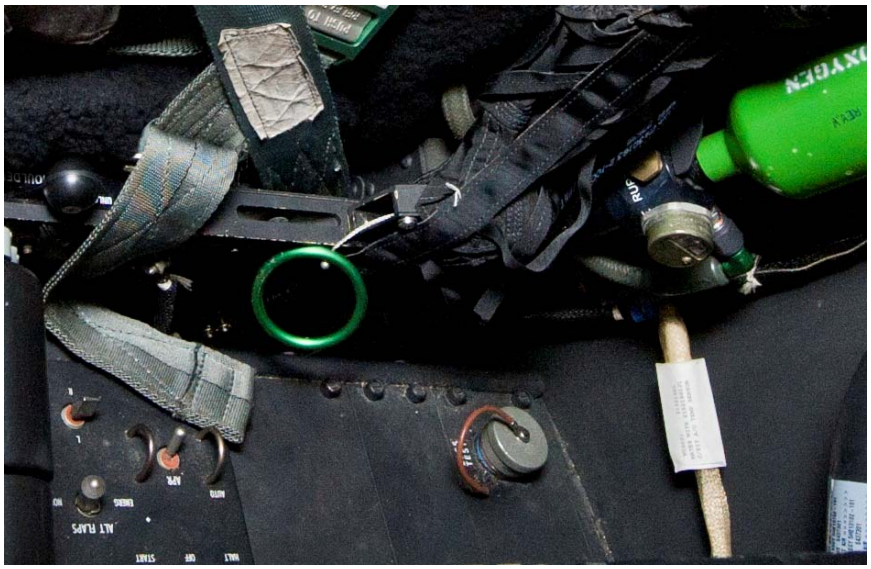

Figure 16- Manual EOS activation ring fallen below lip of seat. (Tab CC-5 and Tab Z-8)

AE101 Inadvertent Operation

Inadvertent Operation is a factor when individual's movements inadvertently activate or deactivate equipment, controls, or switches when there is no intent to operate the control or device. This action may be noticed or unnoticed by the individual. (Tab BB-5)

At 19:42:53L, the MP input a combination of right forward stick and right pedal which initiated a 240 degree descending right roll at greater than 45 degrees per second. At the completion of these stick and pedal inputs at 19:43:08L, the MA had rolled through inverted, experienced less than 1 g of gravitational force, and went from a RWD to LWD attitude, and the descent rate of the aircraft significantly increased. (Tab EE)

These control inputs appeared to be inadvertent because:

1) they had no clear goal or objective.
2) they resulted in an unusual attitude.
3) during ground simulation, when the pilot member repositioned his torso to visually acquire the manual EOS activation ring, he inadvertently actuated the stick and pedals.
4) the MP made no attempt to correct the MA's unusual attitude for 30 seconds after completion of these inputs.

The inadvertent operation of the flight controls placed the MA in an unusual attitude which was unnoticed by the MP. This resulted in the MP's unrecognized spatial disorientation (type 1).

c. Non-Contributory

All human factors were considered for their possible contribution to the mishap sequence. High interest non-contributory human factors include:

PC304 Sudden Incapacitation/Unconsciousness
PC301 Effects of G Forces (G-LOC, etc)
PC312 Hypoxia.

Sudden incapacitation/unconsciousness was considered as a possible human factor. Evidence supports the MP was active in the cockpit during the mishap sequence. The MP was actively flying the MA during the rejoin maneuver when he deliberately placed the MA in a right banked turn with 30 degrees ND. Additionally, intentional aft stick inputs commanding the MA into a 7.4 g pull up maneuver occurred 3 seconds prior to impact, further demonstrating the MP was consciously flying the MA. Sudden incapacitation/unconsciousness was not a factor in this mishap.

The effects of G-Force was considered as a possible human factor. The rejoin maneuver was a low-g maneuver not exceeding 2.5 g until the 7.4 g pull up maneuver 3 seconds prior to impact. Review of the MP's centrifuge training tape demonstrated adequate anti-g strain maneuver and a

resting g tolerance 4.8 g. Furthermore, the MP was a highly trained and experience pilot, familiar with and physiologically conditioned to the effects of high-g maneuvering. The effects of G Forces/G-LOC was not a factor in this mishap.

Hypoxia was considered as a possible human factor. The MP had adequate oxygen supply until 19:42:37L. At that time, the pilot would have experienced restrictive breathing through the oxygen mask. Prior to OBOGS FAIL caution ICAW, the MP should have been receiving adequate supply of oxygen. Due to the high affinity of oxygen to hemoglobin, the MP would have had adequate reserve blood oxygen supply after the OBOGS failed. During the mishap sequence, the MP never activated the EOS or removed his oxygen mask. If the MP had been hypoxic due to the restrictive breathing, the condition would have persisted throughout the mishap and he would not have recovered consciousness to place the aft stick inputs to attempt dive recovery prior to impact. It was concluded that the late recognition of the MA's unusual attitude and appropriate corrective actions attempted by the MP demonstrates that hypoxia was not a factor in this mishap.

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Available Directives and Publications Relevant to the Mishap

(1) Air Force Policy Directive (AFPD) 11-2, Aircraft Rules and Procedures, 14 January 2005
(2) AFI 90-901, *Command Policy*, 1 April 2000
(3) AFI 11-202, Volume 3, *General Flight Rules, Flying Operations*, 5 April 2006
(4) AFI 11-401, *Aviation Management*, 7 March 2007
(5) AFI 90-901, *Operational Risk Management, Command Policy*, 1 April 2000
(6) AFPAM 11-419, *G-Awareness for Aircrew*, 1 December 1999, certified current 29 January 2010
(7) TO 1F-22A-1, *Flight Manual F22A Raptor*, 3 September 2007, change 6 20 September 2010

b. Other Directives and Publications Relevant to the Mishap

(1) AETC Handout, *Flying Training, Introduction to Aerodynamics*, January 2002
(2) Air Force Handbook 203, Volume 1, *Flying Operations, Weather for Aircrews*, 1 March 1997
(3) TO 00-20-1, *Aerospace Equipment Maintenance Inspection, Documentation, Policies, And Procedures*, 30 April 2003, Change 4 - 1 September 2006
(4) Department of Defense Human Factors Analysis and Classification System, 11 January 2005

NOTICE: The AFIs listed above are available digitally on the AF Departmental Publishing Office internet site at: **http://www.e-publishing.af.mil.**

c. Known or Suspected Deviations from Directives or Publications

None

13. ADDITIONAL AREAS OF CONCERN

None

21 July 2011

JAMES S. BROWNE, Brig Gen, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

F-22A, T/N 06-4125
JOINT BASE ELMENDORF-RICHARDSON, ALASKA
16 NOVEMBER 2010

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, if any, may not be considered as evidence in any civil or criminal proceeding arising from the 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

On 16 Nov 2010, at approximately 19:43:27 hours local time (L), an F-22A, Tail Number 06-4125, assigned to the 525th Fighter Squadron, 3rd Wing, Joint Base Elmendorf-Richardson (JBER), Alaska, impacted the ground during controlled flight approximately 120 nautical miles (NM) north of JBER. The mishap pilot (MP) did not attempt ejection and was fatally injured upon impact. The mishap aircraft (MA) impacted near the edge of a valley floor in the Talkeetna Mountain range and was destroyed.

The mishap occurred on a 3-ship night opposed surface attack tactics training mission during the return-to-base portion while the MP was attempting to rejoin with his flight lead. At approximately 19:42:18L, the MA experienced an engine bleed air leak malfunction. The MP began a descent and retarded the throttles to IDLE power. At 19:42:53L, the MA entered a 240 degree roll through inverted and the nose down (ND) pitch attitude increased. At approximately 19:43:24L, the MP initiated a dive recovery. Three seconds later, the aircraft impacted the ground in a left bank at approximately 48 degrees ND at a speed greater than 1.1 Mach (M).

By clear and convincing evidence, I find the cause of the mishap was the MP's failure to recognize and initiate a timely dive recovery due to channelized attention, breakdown of visual scan and unrecognized spatial disorientation.

By preponderance of the evidence, I also find organizational training issues, inadvertent operations, personal equipment interference, and controls/switches were factors that substantially contributed to the mishap.

I developed my opinion by analyzing factual data from historical records, Air Force directives and guidance, engineering analysis, witness testimony, and information provided by technical experts. In addition, the AIB obtained an animation provided by the Aeronautical Systems Center Studies & Analysis Division. I used the animation in conjunction with Lockheed Martin engineering analysis and crash survivable memory unit (CSMU) data to determine the mishap sequence of events.

2. DISCUSSION OF OPINION

a. Cause:

There are several key links in the chain of events that led to this mishap. First, the MA experienced a malfunction. The C BLEED HOT caution ICAW asserted indicating a bleed air leak in the engine bay. According to 1F-F22A-1, a caution ICAW message warns of an aircraft operation that could result in damage to the aircraft, and corrective procedures may be required, but not immediately. The MA isolated the leak and operated as designed throughout the remainder of the MS. The MP appropriately initiated a reduction in power and entered a controlled increased descent.

Second, the MP experienced a restricted breathing condition due to loss of bleed air to the OBOGS as a result of the C BLEED HOT caution ICAW. This required the MP to take action to eliminate the breathing restriction by either manually activating the EOS or lower his oxygen mask. However, recovered evidence indicated the MP had not activated the EOS and the MP's oxygen mask was up and secured in place. The MP demonstrated channelized attention while attempting to rectify the breathing restriction. During the 50 seconds from no airflow to the MP's oxygen mask to initiation of the dive recovery, the board determined the MP prioritized restoring oxygen flow and was not deliberately controlling the MA.

Third, while attempting to rectify the breathing restriction, the MP inadvertently input stick and pedal movements. Although the resulting roll rate, linear acceleration, and less than 1 g gravitational forces were above the perceptible threshold, the MP experienced unrecognized spatial disorientation caused by these inputs due to channelized attention. The resulting increase in ND attitude decreased the time available to recover prior to impact. Figure 17 illustrates the actual descent rate of the MA along with a projected descent rate the MP deliberately intended.

Fourth, the MP's channelized attention led to a breakdown in visual scan. In a single seat aircraft, the pilot is solely responsible for maintaining aircraft control while managing other cockpit tasks. A continuous cross-check of in-flight parameters via cockpit instruments or outside references would have alerted the MP to the MA's attitude and increased descent rate.

Fifth, the MP was late to recognize the necessity for a dive recovery. At 19:43:27L, the MP impacted the ground because his channelized attention and breakdown in visual scan resulted in unrecognized spatial disorientation. When the MP recognized the MA attitude and altitude, he was below minimum recovery altitude. Figure 17 shows the actual initiation of the attempted dive recovery altitude along with the 1F-22A-1 minimum recovery altitude.

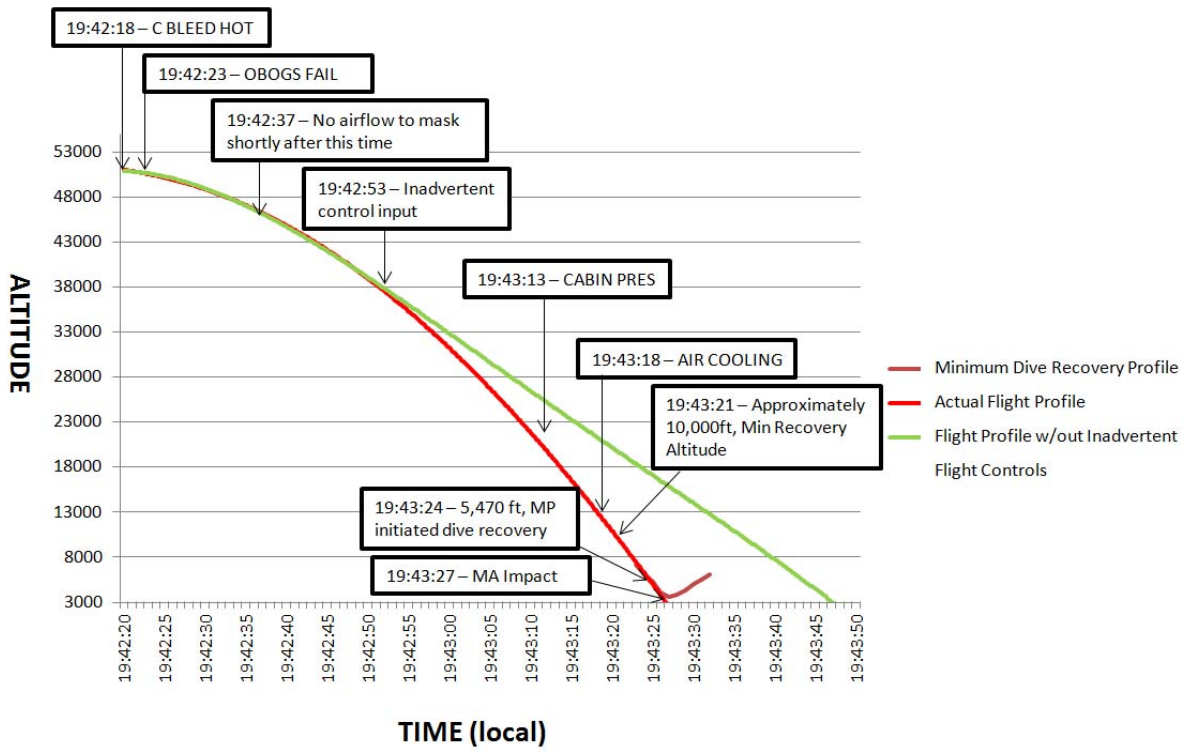

Figure 17 Flight profiles for MS. Actual flight profile (red), flight profile without inadvertent flight control inputs (green), and minimum altitude dive recovery profile (maroon) shown.

b. Contributing Factors.

Numerous additional factors substantially contributed to this mishap, including:

(1) Organizational Training Issues

The MP was an experienced fighter pilot and was highly trained to handle complex aircraft emergencies. The MP had recently reviewed the procedures for the MA malfunction during monthly Supervised Emergency Procedure Training. However, procedure training does not simulate the physiological stressors of real world in-flight and cockpit conditions during emergency situations, for example, restricted breathing, gravitational forces, cockpit pressurization, etc.

Recovered evidence indicated the MP's oxygen mask was up and secured in place, and the MP had not activated the EOS. During the MS, the MP most likely experienced a sense similar to suffocation when airflow to the oxygen mask stopped. This was likely the MP's first experience under such physiological duress. The unique and added stress of the breathing restriction contributed to the MP's channelized attention.

(2) Inadvertent Operations

At 19:42:53L, the MP began a 20-second series of stick and pedal movements which resulted in the previously discussed unusual attitude. The board determined these inputs to be inadvertent because they had no deliberate goal or objective. The movements caused:

- The ND attitude to increase, accelerating the descent rate to greater than 1,000 feet per second,
- Less than 1 g gravitational force in the cockpit,
- Reversed the MP's intended turn direction while rolling through inverted flight.

In addition, the movements would be disorienting during nighttime flight conditions. The board determined that the MP inadvertently made flight control inputs while attempting to restore airflow to the oxygen mask.

(3) Personal Equipment Interference

The MP was wearing CAT III cold weather gear and NVGs during the MS. Ground simulation demonstrated reduced mobility in the cockpit due to the bulkiness of CAT III gear. Additionally, the NVGs hit the canopy, interfering with the pilot's ability to look from side to side and down at the consoles. In order to obtain head/canopy clearance, the pilot had to shift his torso by bracing himself on various areas in the cockpit. These bracing actions and limited tactile sensation due to the CAT III gear demonstrated how inadvertent flight control inputs could occur.

(4) Controls and Switches

The EOS activation ring is seated on the left aft edge of the ejection seat. A two-step process is required to manually activate the EOS system. The pilot must unseat the ring and pull directly forward with a force that may be in excess of 40 lbs. The ring travels approximately two inches and remains connected to the seat via a lanyard. During ground simulation, the EOS manual activation ring was unseated and dropped between the seat and console prior to EOS activation. This was done to simulate a failed initial pull, which may have occurred for various reasons, including: the EOS activation ring was dropped or the EOS cable jammed during an attempted manual activation. Retrieval of the ring from between the seat and console would be difficult based on the seat position, night environment, and with personal equipment interference.

3. CONCLUSION

By clear and convincing evidence, I find the cause of the mishap was the MP's failure to recognize and initiate a timely dive recovery due to channelized attention, breakdown of visual scan and unrecognized spatial disorientation. Further, I find by preponderance of evidence, organizational training issues, inadvertent operations, personal equipment interference, and controls/switches were factors that substantially contributed to the mishap.

21 July 2011

JAMES S. BROWNE, Brig Gen, USAF
President, Accident Investigation Board

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