EXECUTIVE SUMMARY

AIRCRAFT ACCIDENT INVESTIGATION

F-15C, T/N 80-0034
LAMBERT FIELD IAP, MISSOURI
2 NOVEMBER 2007

On 2 November 2007, at 0950 Central Standard Time (CST), four F-15C Eagle aircraft departed Lambert Field International Airport (Lambert Field IAP), St. Louis, Missouri (MO) to conduct an air-to-air training mission. At approximately 1011 CST, one of the F-15 aircraft, tail number 80-0034, broke apart in flight and impacted the ground in a wooded area approximately 4 miles south-southeast of Boss, MO; approximately 90 miles south-southwest of Lambert Field IAP. Despite injury to his left shoulder and arm caused by the in-flight breakup, the mishap pilot (MP) ejected successfully and parachuted to the ground. The MP was recovered by local rescue personnel and transported via Life Flight to a St. Louis-area hospital for medical treatment. The mishap aircraft (MA) was based at Lambert Field IAP and assigned to the 110th Fighter Squadron, of the 131st Fighter Wing. The mishap mission was flown in the Lindbergh and Salem Military Operating Areas (MOAs). Lindbergh and Salem MOAs are above predominately agricultural land and forest located approximately 70-150 miles to the southwest of St. Louis, MO. The MA was destroyed upon impact, and the resultant wreckage caused minimal damage to private property.

The mishap flight's mission was to conduct Basic Fighter Maneuvers involving one-on-one offensive attack and defensive maneuvering. During the MP's second engagement, he maneuvered in a nearly level right-hand turn at approximately 450 knots. With less than 7.8 times the force of gravity (G) loaded upon the aircraft, the MA began shaking violently side to side. The MP then transmitted, "Mick 2, knock it off!," while simultaneously rolling wings level and reducing to 1.5 Gs. Within seconds the forward fuselage broke apart from the aft portion of the MA. The MP successfully ejected after the in-flight break-up.

The accident investigation board president found, by clear and convincing evidence, the cause of this accident was a failure of the upper right longeron, a critical support structure in the F-15C aircraft. The MA upper longeron failed to meet blueprint specifications increasing localized stress in the thin web and leading to crack initiation. Engineering and metallurgy analysis of the recovered MA wreckage identified a fatigue crack in the thin web of the longeron near canted fuselage station (CFS) 377 which grew under cyclical flight loads and ultimately led to longeron failure. The longeron failure subsequently triggered a catastrophic failure of the remaining support structures and caused the aircraft to break apart in-flight.

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 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-15C, T/N 80-0034
2 November 2007

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COMMONLY USED ACRONYMS AND ABBREVIATIONS

110 FS	110th Fighter Squadron
131 FW	131st Wing
623	Air Force Form 623, On-the-Job-Training Record
797	Air Force Form 797, Job Qualification Standard Continuation
ACC	Air Combat Command
ACES II	Advanced Concept Ejection Seat II
ACM	Air Combat Maneuver
AESG	Aeronautical Systems Group
AF	Air Force
AFB	Air Force Base
AFI	Air Force Instruction
AFIP	Air Force Institute of Pathology
AFMAN	Air Force Manual
AFRL	Air Force Research Laboratory
AFSC	Air Force Specialty Code
AFTO 781	Aircraft Forms Technical Order 781 Series
AGE	Aerospace Ground Equipment
AIB	Aircraft Investigation Board
AIM 9	Heat-Seeking Missile
ALS	Aircrew Life Support
AMU	Aircraft Maintenance Unit
AMXS	Aircraft Maintenance Squadron
ATC	Air Traffic Controller
AUX	Auxiliary
BFM	Basic Fighter Maneuver
BINGO	Minimum Fuel Required to Head Home
Boeing	Boeing Aircraft Company
C	Celsius
CAMS	Computer Automated Maintenance System
CAS	Control Augmentation System
CFS	Canted Fuselage Station
CMD	Countermeasure Dispenser
CSAR	Combat Search and Rescue
CST	Central Standard Time
CT	Continuation Training
Dash-1	A.F.T.O. 1F-15C-1 Flight Manual
DSN	Defense Switch Network
ECS	Environmental Control System
EEC	Electronic Engine Control
EOR	End of Runway
EP	Emergency Procedures
EPE	Emergency Procedures Evaluation
ER	Exceptional Releases
F-15C	F-15C Eagle
FDP	Flight Duty Period
FEM	Finite Element Model
FL	Flight Lead
FMC	Fully Mission Capable
FMT	Flight Mission Trainer
FO	Foreign Object
FOD	Foreign Object Damage
FS	Fighter Squadron/Fuselage Station
FTU	Flying Training Unit
ft	Feet
G	Force of Gravity
HPO	Hourly Post Flight Inspection
HUD	Heads up Display
ICS	Intercommunication Systems
IDG	Integrated Drive Generators
IFE	In-Flight Emergency
IMDS	Integrated Maintenance Data System
IP	Instructor Pilot
JOAP	Joint Oil Analysis Program
K	Thousand
Lambert Field IAP	Lambert Field International Airport
Lindy	Lindbergh MOA
LOX	Liquid Oxygen
MA	Mishap Aircraft
MAJCOM	Major Command
MF	Mishap Flight
MFL	Mishap Flight Lead
MO	Missouri
MOA	Military Operating Area
MoANG	Missouri Air National Guard
MOC	Maintenance Operations Control
MP	Mishap Pilot
MPCD	Multi-Purpose Color Display
MQT	Mission Qualification Training
MSL	Mean Sea Level
NOTAMS	Notices to Airmen
OG	Operations Group
OTI	One Time Inspection
PA	Public Affairs
PDM	Programed Depo Maintenance
PE	Periodic Inspection
PLF	Parachute Landing Fall
QA	Quality Assurance
QC	Quality Check
QUAL	Qualification
RAP	Ready Aircrew Program
RED X	Safety of Flight
RESCAP	Rescue Combat Air Patrol
RPM	Revolutions Per Minute
RTB	Return to Base
RTU	Replacement Training Unit
S/N	Serial Number
SAR	Search and Rescue
SEFE	Standardization Evaluation Flight Examiner

SEPT	Situational Emergency Procedure Training
Sortie	Flight
Stan Eval	Standardization and Evaluation
T/N	Tail Number
TACAN	Tactical Aid to Navigation
TCTO	Time Compliance Technical Order
TEWs	Tactical Electronic Warfare Systems
TI	Tactical Intercept
TO	Technical Order
US	United States
USAF	United States Air Force
UWARS	Universal Water Activated Release System
VFR	Visual Flight Rules
VTR	Video Tape Recorder

SUMMARY OF FACTS

1. AUTHORITY, PURPOSE, AND CIRCUMSTANCES

a. Authority

On 7 November 2007, General John D.W. Corley, Commander, Air Combat Command (ACC), appointed Colonel William Wignall, to conduct an aircraft accident investigation of a mishap that occurred on 2 November 2007 involving an F-15C aircraft, tail number (T/N) 80-0034 in Dent County, Missouri (MO). (Tab Y-2) The investigation was performed in accordance with AFI 51-503, Aerospace Accident Investigations, and was conducted at Lambert Field International Airport (Lambert Field IAP), from 7 November 2007 through 13 December 2007. The board members were: Lieutenant Colonel Jimmy Bardin (Legal Advisor), Lieutenant Colonel Matthew Wessel (Pilot), Lieutenant Colonel Charles Kowitz (Investigating Officer), Major Robert Botkin (Maintenance), Major Kerry Murphy (Flight Surgeon), Major Eric Dopslaf (Assistant Investigating Officer), Captain Alexandra O'Hanley (Assistant Legal Advisor), Senior Master Sergeant Jeffrey Managhan (Life Support), Master Sergeant James Martinez (Paralegal), and Technical Sergeant Virginia Race (Transcriptionist). (Tab Y-2)

b. Purpose

The purpose of this investigation was to provide a publicly releasable report of the facts and circumstances surrounding the accident, including a statement of opinion on the cause or causes of the accident; to gather and preserve evidence for claims, litigation, disciplinary and administrative actions; and for other purposes. This report is available for public dissemination under the Freedom of Information Act (5 United States Code (U.S.C.) § 552) and Air Force Instruction (AFI) 37-131, *Freedom of Information Act Program,* published on 16 February 1995. This investigation is separate and apart from any safety investigation conducted pursuant to AFI 91-204, *Safety Investigations and Reports*, published on 14 February 2006, for the purpose of mishap prevention.

c. Circumstances

The accident investigation board (AIB) was convened to investigate a Class A mishap involving an F-15C aircraft, T/N 80-0034, assigned to the 131st Fighter Wing (131 FW), Lambert Field IAP, MO, which occurred during a training mission on 2 November 2007.
(Tab Y-2)

2. ACCIDENT SUMMARY

The mishap aircraft (MA), an F-15C, T/N 80-0034, departed Lambert Field IAP, at 0950 Central Standard Time (CST) on 2 November 2007, to conduct an air-to-air training mission. Approximately 21 minutes later, at a position approximately 90 miles south-southwest of Lambert Field IAP, the mishap pilot (MP), Major Stephen Stilwell, experienced violent shaking of the MA's forward fuselage. Seconds later, the aircraft broke into two pieces as the forward

fuselage separated from the main fuselage just aft of the cockpit. The MP successfully ejected from the aircraft prior to impact, but he sustained a dislocated left shoulder and shattered bone in his upper left arm. Civilian personnel responded to the mishap, recovered the MP, and transported him to a St. Louis-area hospital via a Life Flight helicopter. The MP received treatment for his injuries and was released. The MA was destroyed upon impact. The two parts of the fuselage landed approximately a half mile apart on a wooded hillside, causing minimal damage to private property. (Tab P-4) Financial loss to the Air Force totaled $41,749,726. (Tab P-2, P-3)

3. BACKGROUND

The 131 FW is located approximately 20 miles northwest of downtown St. Louis, MO and adjacent to the main terminal at Lambert Field IAP. The 131 FW is a reserve component of ACC, and its mission is to achieve and maintain air superiority with the United States Air Force (USAF) F-15 Eagle aircraft originally built by McDonnell Douglas (now Boeing Aircraft Company (Boeing)). Currently, there are 1,591 military members assigned to the wing and its subordinate units; all of which are components of the State of Missouri Air National Guard (MoANG). The 110th Fighter Squadron (110 FS), a subordinate unit of the 131 FW, flies the F-15C/D Eagle. Routine training consists of basic fighter maneuvers (BFM) missions designed to improve air-to-air combat skills.

The F-15C/D Eagle is an all-weather, extremely maneuverable, tactical fighter designed to gain and maintain air supremacy over the battlefield. The Eagle's air superiority is achieved through outstanding maneuverability and acceleration, range, weapons and avionics. The F-15 has electronic systems and weaponry to detect, acquire, track and attack enemy aircraft while operating in a friendly or enemy-controlled airspace. The weapons and flight control systems are designed so one person can safely and effectively perform air-to-air combat.

The first F-15A flight was accomplished in July 1972; however, the Eagle wasn't delivered to a combat squadron until two years later. Beginning in 1979, the single-seat F-15C and two-seat F-15D models, utilized for pilot training tasks, entered the Air Force inventory. The MoANG acquired the F-15A Eagle in 1991 and gradually replaced them with F-15C/D models in 2005.

F-15C/D aircraft were deployed to the Persian Gulf in 1991 in support of Operation Desert Storm where they proved their superior combat capability. F-15C fighters accounted for 34 of the 37 Air Force air-to-air victories. They have since been deployed in support of air expeditionary force deployments to Operations Provide Comfort and Northern Watch at Incrilik Air Base (AB), Turkey, Operation Southern Watch (no-fly zone in Southern Iraq), Allied Force in Bosnia, and Operations Enduring Freedom in Afghanistan and Iraqi Freedom in Iraq.

4. SEQUENCE OF EVENTS

a. Mission

The mishap mission was authorized by the 110 FS Director of Operations and was scheduled to take place 70-150 miles southwest of St. Louis in the Lindbergh and Salem Military Operating

Areas (MOAs). (Tab K-3 thru K-4, K-7 thru K-8, S-3). The mission was planned and briefed as basic fighter maneuver (BFM) training involving four F-15Cs with the callsigns Mick 1, Mick 2, Mick 3 and Mick 4. (Tab K-7 thru K-8, V-1.4 thru V-1.6, V-2.3, V-3.4) Mick 1 was the mishap flight lead (MFL) and Mick 2 was the MP. (Tab V-1.6, V-2.3) Mick 3 and Mick 4 were part of the mishap flight (MF), but upon reaching the airspace split from the flight to conduct their own BFM training. (Tab V-1.9 thru V-1.10, V-2.3 thru V-2.4) Mick 1 and Mick 2 operated in the center of the MOA while Mick 3 and Mick 4 conducted training in the western portion of the MOA. (Tab V-1.9, V-2.6)

BFM training consists of one fighter aircraft attacking another fighter aircraft within visual range of each other at pre-determined parameters of airspeed, altitude and distance between the aircraft. For this mission, the MP was the offensive fighter starting 9,000 feet (ft) behind the MFL and 40 degrees off the MFL's tail. (Tab V-1.10 thru V-1.12, V-2.6 thru V-2.7) The mission served as continuation training (CT) for Mick 1 and Mick 2. (Tab K-7)

b. Planning

Mick 1 planned and briefed the CT BFM sortie. The original planned training involved Air Combat Maneuvers (ACM), but Mick 1 modified the mission to separate BFM training because Mick 4 had not flown in the 30 days prior to 2 November 2007. (Tab V-2.3 thru V-2.4, V-3.4, V-4.4, K-7, G-23)

At 0745 CST on 2 November 2007, the operations supervisor briefed all pilots scheduled to fly that morning. (Tabs V-3.4, V-4.4, K-9 thru K-17) The mass briefing and the Mick flight coordination briefing were conducted in accordance with AFI 11-2F-15, Vol. 3, *F-15 Flying Operations,* published on 25 October 2005. (Tab V-1.6, V-2.5, V-3.4) The briefings covered administrative flight information, weather, Notices to Airman (NOTAMS), training rules and all items necessary to safely execute the planned BFM and alternate ACM training. (Tab V-1.6, V-2.4 thru V-2.5, V-3.8 thru V-3.9, F-3 thru F-14) According to witness interviews, the Mick flight pilots left the brief with a clear understanding of the primary and alternate missions. (Tab V-3.9)

After the coordination briefing, Mick 2, 3 and 4 proceeded to the Flight Mission Trainer (FMT) to complete Situational Emergency Procedure Training (SEPT) in accordance with AFI 11-2F-15, Vol. 1, *F-15 Aircrew Training,* published on 9 January 2007. (Tab V-1.7, V-3.4) All required emergency procedures were discussed and practiced. (Tab V-3.4)

c. Preflight

Mick flight received a final brief, conducted by the operations supervisor pursuant to AFI 11-418, *Operations Supervision,* dated 20 March 2007, before departing the squadron for the flight line. (Tab BB-2 thru BB-5, V-1.7, V-3.8, V-4.4) The brief addressed jet status and included a final check of the weather and NOTAMs. (Tab V-1.7, V-3.8, K-7 thru K-16, F-3 thru F-15) After arriving at the aircraft, the MP reviewed the MA forms and conducted an aircraft pre-flight walk-around. (Tab V-1.7) Engine start, taxi, and end-of-runway (EOR) final checks were uneventful. (Tab V-1.8, V-2.6, V-3.4)

d. Summary of Accident

Mick flight took off at 0950 CST and proceeded towards the Lindbergh and Salem MOAs as planned and briefed. (Tab V-1.8, V-2.6, V-3.5, V-4.5) On the way to the airspace Mick flight rejoined in a visual formation at an altitude of 21,000-22,000 ft, completing all required in-flight checks. (Tab V-1.9, V-2.6, V-3.5) Upon entering the Lindbergh MOA, Mick 1 directed Mick 3 and 4 off to the west side of the airspace. (Tabs V-1.9, V-2.6, V-3.5, V-4.5) Mick 1 and 2 then completed a force of gravity (G) warm-up exercise by completing two 180 degree turns loading 4-5 Gs upon the aircraft to assess proper functioning of their equipment and to prepare themselves for the high G-forces encountered during BFM training. (Tab V-1.10, V-2.6, N-3) During the training mission, Mick 2 was designated as the attacker and Mick 1 as the defender. (Tab V-1.10 thru V-1.11, V-2.6 thru V-2.7)

The MP's first engagement was an offensive BFM beginning at 9,000 ft of aircraft separation and 18,000 ft mean sea level (MSL). This engagement was executed as planned and was uneventful. (Tab V-1.10 thru V-1.11, V-2.6 thru V-2.7, N-3 thru N-4)

The MP's second engagement was another offensive BFM beginning at 9,000 ft of aircraft separation, also at 18,000 ft MSL. (Tab V-1.11, V-2.7, N-4) The aircraft flew parallel to each other, 2.4 nautical miles apart in a line abreast, tactical formation. (Tab V-1.11, V-2.7) The MP was on the east side of the formation as they proceeded northbound. (Tab V-1.11, V-2.7) The MFL began the engagement by turning the flight 45 degrees to the left and then reversed his turn. (Tab V-1.11, V-2.7, N-4) The MP obtained a radar lock on the MFL from a distance of 12,000 ft and began counting down the range between the two aircraft. At a distance of 9,000 ft, the MP transmitted over the radio, "9,000, fight's on." (Tab V-1.12, V-2.7, N-4) At the "fight's on" call, the MFL began an 8 G break turn to the right. (Tab V-2.7 thru V-2.8) The MP momentarily rolled wings level, accelerated to 453 knots, and initiated an offensive break turn by smoothly increasing the G-load on the aircraft to 7.8 Gs. (Tab V-1.12 thru V-1.13)

While in his offensive break turn, but prior to reaching 7.8 Gs, the MA began shaking violently side to side. The MP transmitted, "Mick 2, Knock it off!", while simultaneously rolling wings level and reducing the G-load on the aircraft to 1.5 Gs. (Tab V-1.13, V-2.8) The MFL echoed the MP's call stating, "Mick 1, knock it off!" (Tab V-2.8, N-4) The MFL then saw the MA break apart just behind the cockpit and transmitted, "Eject! Eject!" (Tab V-2.8, N-4) The MP initiated the ejection sequence at 1011:47 CST. (Tab N-4)

e. Impact

After the MP ejected, the MA impacted the ground in a wooded area approximately 4 miles south-southeast of Boss, MO. Coordinates of the main fuselage impact site are North 37 degrees 35 minutes 50 seconds by West 91 degrees 10 minutes 13 seconds. (Tab J-23) The forward fuselage impacted at North 37 degrees 36 minutes 10 seconds by West 91 degrees 10 minutes 08 seconds, approximately a half mile from the main fuselage. (Tab J-23) The main fuselage landed flat on its belly, slightly nose low, and burned until the fuel supply was depleted. There was no evidence of fire at the site of the forward fuselage impact. Pieces of aircraft debris were scattered across an area approximately a 1/2 mile wide and 3 miles long. (Tab J-23) Local authorities secured the crash site until investigators arrived. Wreckage debris was located and

global positioning coordinates were recorded for investigation purposes before it was transported from the crash site to Lambert Field IAP, MO. (Tab Q-3).

f. Life Support Equipment, Egress and Survival.

While the MA was in a right turn approaching 7.8 Gs, the MP detected a problem with the MA. (Tab V1.12 thru V1.14) As the MP rolled the MA out of the turn, it broke apart. The MP then initiated ejection at approximately 18,000 ft MSL. (Tab V-1.15)

The F-15C aircraft is equipped with an Advanced Concept Ejection Seat II (ACES II). (Tab H-3 thru H-4) The MP ejected within the rated airspeed and altitude parameters of the ACES II. According to the MFL, the MP ejected within the mode III ejection envelope, which is defined as ejections occurring above 15,000 ft MSL. (Tab H-3 thru H-4) All systems within the ACES II ejection seat functioned as designed. (Tab H-3)

After initiating ejection, the MP descended in the ejection seat to approximately 15,000 ft, at which time the seat automatically released the drogue chute. (Tab V-1.15 thru V-1.16) The drogue chute is designed to slow the seat and control decent above 15,000 ft. After the drogue chute released, the MP was separated from the seat and his recovery parachute deployed as designed.

During descent, the MP performed his post-ejection checklist to ensure his parachute canopy was in good condition and the survival kit was deployed. (Tab V-1.16) He then completed a two-line jettison procedure to reduce the parachute oscillation and execute a more controlled landing. (Tab V-1.16) Because of injuries to his left shoulder and arm caused by the in-flight break up, the MP did not attempt to remove his mask or accomplish a four-line jettison; he steered the parachute exclusively with his right hand. (Tab V-1.16)

Prior to landing, the MP stabilized his left arm to protect himself from additional injury. (Tab V-1.19) The MP accomplished a parachute landing fall (PLF), a parachute landing procedure designed to minimize injury, to the right to avoid trees. (Tab V-1.19)

After landing, the MP released his left parachute riser and then the right parachute risers. (Tab V-1.20) The MP then performed an injury self-assessment without moving to prevent further injury to his left shoulder and arm. (Tab V-1.20) A local resident arrived on scene shortly after the mishap, retrieved the radio from the MP's survival kit and offered it to the MP. The MP, concerned he would aggravate his injuries, opted to not use the radio. (Tab V-1.24) Records indicate life support survival equipment and egress inspections were current. (Tab H-10 thru H-11)

The Accident Investigation Board (AIB) life support technical advisor examined the MP's recovered equipment and identified the following damage: scratches on back and sides of the helmet; broken visors ripped off the helmet; and a shredded pencil pocket on the left sleeve of the MP's flight suit. (Tab H-11) The technical advisor also noted a slide fastener was torn from the right leg of the anti-G suit that was later recovered from the cockpit wreckage. (Tab H-11) Additionally, there was a dent in the ejection seat rail and the left pitot tube of the parachute container was damaged. (Tab H-4)

g. Search and Rescue (SAR)

At 1011:50 CST Mick 1 called, "Knock it off! Knock it off!" over the area common radio frequency and then, acting as the on-scene commander, directed Mick 3 and 4 to switch to Mick 1's frequency. (Tab V-3.5, N-4) While circling the crash site, Mick 1 confirmed he saw a parachute and passed the coordinates of the crash site to the operation supervisor through Mick 3. He then instructed Mick 4 to contact Kansas City Center with the coordinates of the crash site and inquire about helicopters in the area. (Tabs V-3.11, V-4.6, N-4 thru N-6)

At 1022:45 CST, Mick 1 reported Mick 2 was on the ground. (Tab N-7) Mick 1 radioed he saw cars on a road about 100 feet north of Mick 2's location. (Tab N-12) Mick 1 continued to circle the crash site until 1040 CST when he reached "bingo" fuel, a predetermined fuel state requiring the pilot to return to base. He then transferred responsibility of the on-scene commander to Mick 3. (Tab V-3.6, N-11 thru N-12) Mick 3 and Mick 4 remained above the crash site until arrival of the Life Flight helicopter, at which time they returned to Lambert Field IAP. (Tabs V-3.6 thru V-3.7)

Because of injuries to his left arm and shoulder, Mick 2 chose not to use any of his survival equipment. (Tab V-1.20) Local residents were the first to find Mick 2 and tried to assist him. (Tab V1.22) Unaware of the extent of his injuries, Mick 2 directed the local residents to get help and not touch him or his equipment. (Tab V1.22 thru V1.24) Local law enforcement arrived within minutes and coordinated Mick 2's immediate care. (Tab V1.24) Approximately 30 minutes after Mick 2 ejected, Life Flight personnel transported him to Barnes Jewish Hospital in St. Louis, MO. (Tab V1.24 thru V1.25)

h. Recovery of Remains

Not applicable.

5. MAINTENANCE

a. Forms Documentation

Maintenance history for Air Force aircraft is manually documented in the Aerospace Vehicle Flight Report and Maintenance Record (commonly referred to as the Aircraft Forms Technical Order Form 781 series (AFTO 781)) and in two computer database systems, the Core Automated Maintenance System (CAMS) and the Integrated Maintenance Data System (IMDS). The AFTO 781 is a hard-copy record of the complete history and current status of each aircraft to include discrepancy and malfunction information. CAMS is predominately the maintenance unit's working electronic record of aircraft repairs and personnel time accountability. IMDS is an electronic management database designed to generate more complex reports than CAMS.

According to AFTO 781 historical data, at the time of the mishap the MA had flown a total of 5,868.2 hours and was fitted approximately one year ago with two Pratt & Whitney F-100/100 engines. (Tab D-3) Maintenance records indicate MA's #1 engine (left engine) operated a total of 6,354.1 hours and MA's #2 engine (right engine), operated a total of 8,295.8 hours. (Tab D-3)

During the 90 days prior to the accident, the MA flew 19 sorties for a total of 31.7 hours. (Tab U-3 thru U-161) The MA's active and historical AFTO 781 did not reflect pre-existing engine, mechanical, or, structural discrepancies. Additionally, there were no electrical failures or flight control anomalies annotated in the maintenance records. (Tab D-4 thru D-23) CAMS records for 90 days prior to the mishap confirmed all of the AFTO 781 data (Tab D-3 thru D-23). According to CAMS, the MA had a single outstanding Time Compliance Technical Order (TCTO) 1F-15-1543, for a pending egress system maintenance; however, the TCTO did not restrict the MA from flying. (Tab D-10 thru D-23)

b. Inspections

Phase inspections are regularly-scheduled maintenance performed on Air Force aircraft at pre-determined flying hour intervals. The F-15 has a reoccurring 200- flight hour phase inspection cycle known as the Hourly Post-Flight inspection (HPO). The MA maintenance crew completed a more extensive 200-flight hour inspection at the 600 HPO between 26 March 2007 and 9 April 2007. (Tab D-3) During the 600 HPO, all scheduled/unscheduled maintenance, inspections, delayed discrepancies, outstanding TCTOs, and One Time Inspections (OTI) were completed and properly documented. The next scheduled 200-flight hour phase inspection would have been due in approximately 134 flight hours. (Tab D-17) At 1200-flight hour intervals, aircraft undergo a more comprehensive inspection known as a Periodic Inspection (PE). This inspection is performed at the depot on Warner-Robbins Air Force Base (AFB), Georgia. The last Programmed Depot Maintenance (PDM) was completed on 9 November 2003. (Tab D-3)

The MA was equipped with two Pratt and Whitney F100-100 engines. (Tab D-17) These engines were overhauled according to a time replacement schedule determined by the engine cycles (starts), general operating time, and operating time above certain temperatures. (Tabs B-18, D-3) The engines are inspected prior to each flight and receive more extensive inspections during HPO inspections and at specific times during the engine life cycle.

The MA's left engine was installed on 24 October 2006, and operated 231.3 hours in the 90 days prior to the 2 November 2007 mishap. (Tab D-3) The MA's right engine was installed on 6 December 2006, and operated 177.2 hours in the 90 days prior to the mishap. (Tab D-3) Neither engine had any outstanding TCTOs, any significant post-installation engine maintenance or any unscheduled maintenance relevant to the mishap. (Tab D-17 thru D-24)

At 0830 CST, on the day of the mishap, a routine preflight inspection was conducted on the MA, (Tab D-4) The maintenance documentation indicates that all MA inspections were accomplished in accordance with AFI 21-101, *Aircraft and Equipment Maintenance Management*, published on 29 June 2006.

c. Maintenance Procedures

An extensive review of all documentation revealed maintenance procedures, practices and performance were in compliance with Technical Order (TO) specifications (Tab D-3 thru D-24). As of 2 November 2007, the date of mishap, no inspection requirements existed for detecting a

crack in the longeron. Inspection criteria for the forward fuselage were never developed because during initial fatigue testing on the aircraft, no fatigue failures or cracks were detected in the forward fuselage structures.

d. Maintenance Personnel and Supervision

Interviews conducted with maintenance personnel confirm all preflight activities were normal and all personnel involved in the MA preflight and launch were experienced and qualified. (Tabs G-56, V-5 thru V- 15) Maintenance supervisors were engaged in daily maintenance activities and actively involved in the repair and launch of aircraft. Maintenance training records including AF Form 623 (Individual Training Record), Career Field Education and Training Plans and AF 797 (Job Qualification Standard Continuation/Command JQS) were reviewed for personnel involved with the MA. The MA crew had current, adequate training and certifications in accordance with Air Force directives. (Tab G-56) Collectively, the crew members maintained the required skill levels, experience, and qualifications to perform all assigned duties. (Tab G-56) The MA preflight servicing, weapons loading operations, end of runway inspections, supervision, and performance complied with all current TOs and instructions.

e. Fuel, Hydraulic and Oil Inspection Analysis

Periodically, engine oil samples are taken and analyzed for possible contamination and engine wear. This process is called the Joint Oil Analysis Program (JOAP). The last JOAP sample, taken 31 October 2007, revealed no engine abnormalities. (Tab D-28 thru D-29)

Air Force Manual (AFMAN) 91-223, *Aviation Safety Investigation and Report,* published on 6 July 2004, mandates mishap investigators take samples of the Liquid Oxygen (LOX), oil and hydraulic fluids from the MA servicing equipment for testing. A LOX sample was not obtained because of a leak in the servicing equipment; however, all other servicing equipment test results were normal. (Tab D-25 thru D-27) No evidence was found that servicing equipment contributed to the mishap. Collection and analysis of post-mishap fluids were not possible due to the catastrophic damage to the MA.

f. Unscheduled Maintenance

A comprehensive review of the MA AFTO 781 records from 90 days prior to the mishap revealed that unscheduled maintenance actions were not relevant to this mishap. (Tab U-3 thru U-161)

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

a. Condition of Systems

Although the aircraft was destroyed in the mishap, significant portions were recovered and examined. The aircraft wreckage debris field was spread over an area approximately a 1/2 mile wide and 3 miles long. (Tab J-53, J-128) Technical experts evaluated the wreckage on site and then reconstructed portions of the wreckage in a cradle at Lambert Field IAP. Additionally,

pieces of the MA wreckage were sent to Boeing and Air Force Research Laboratory (AFRL) materials laboratories for additional analysis.

b. Analysis of Engines

The engines were examined at the main wreckage site. Technical experts determined at the time of the mishap, the MA engines were operating normally and engine damage was consistent with ground impact. (Tab J-9, J-133)

c. Analysis of Cockpit Canopy System

The MA cockpit canopy was found in the debris field detached from the aircraft. (Tab J-23, J-128) The canopy glass was shattered and the forward rails and frame were broken. The MA canopy damage was consistent with abnormal in-flight release. Normally, during the ejection sequence, the canopy remover strikes a release mechanism which unlocks the canopy; however, the MA canopy remover never made contact with the release mechanism and the canopy locks remained in the locked position. (Tab J-12, J-130) Dents and markings in the cockpit indicate the canopy struck the ejection seat rail as it departed the MA prior to the MP's initiating the ejection sequence. (Tab J-12, J-13) Abnormal release of the canopy during in-flight breakup did not compromise ejection.

d. Analysis of Flight Controls

All flight control surfaces were examined at the main fuselage wreckage site. The right vertical stabilizer and rudder broke free from the MA at ground impact and is considered secondary damage to fuselage break up. (Tab J-9) Comparison between Boeing's analysis of the MA cockpit head-up display (HUD) data and simulator data indicates the flight controls were operating normally prior to fuselage break up. (Tab J-28, J-127)

e. Analysis of Environmental Control System

All environmental control system (ECS) bay components from the MA were recovered and evaluated. There was no evidence of MA ECS component failure as a result of fire, explosion, or detachment from the mounting structure. (Tab J-14, J-131)

f. Analysis of Ejection System and Life Support Equipment

The MA ejection system operated properly in Mode III ejection. (Tab H-6) The MP's life support equipment was sent to the 77th Aeronautical Systems Group for evaluation. Analysis confirmed the MP's life support equipment functioned properly and reported damage is consistent with the ejection, break-up and recovery events. (Tab H-20 thru H-39)

g. Analysis of Landing Gear System

Engineering experts determined the MA's main landing gear was extended and the nose landing gear retracted at ground impact. (Tab J-14) Separation of the forward fuselage from the main fuselage pulls the emergency landing gear cable in tension. This allows the gear to free fall to the down and locked position. No electrical power or hydraulic power is necessary to extend the

gear in the emergency mode. The positioning of the landing gear in the debris field is consistent with in-flight break-up of the aircraft fuselage and subsequent damage to the emergency extension system. (Tab J-14 thru J-15)

h. Analysis of Structural Failure

Evaluation of the MA forward fuselage wreckage and main fuselage wreckage in the debris field indicates the MA broke apart in flight at the canted fuselage station (CFS) 377 bulkhead. (Tab J-12, J-13, J-61, J-127)

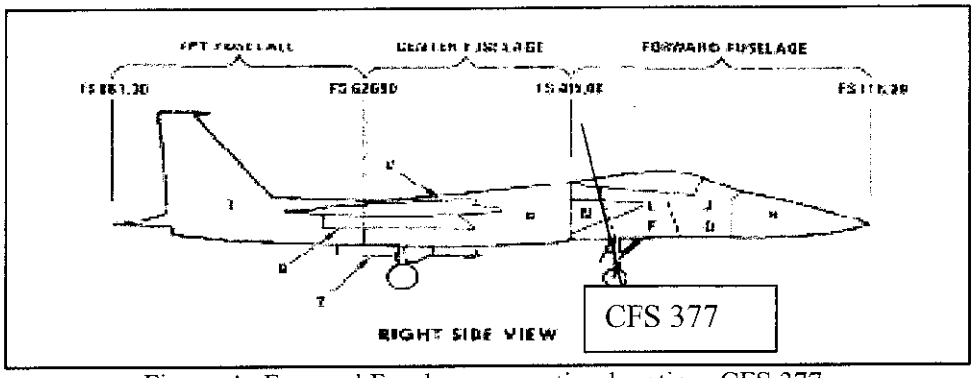


Figure A, Forward Fuselage separation location, CFS 377.

The engineering report states the MA break-up was initiated by failure of the right upper longeron just forward of the CFS 377 bulkhead splice. The upper longerons in the forward fuselage are single load-path structures. Failure of either longeron will result in loss of the structural capability to carry the applied loads. (Tab J-13, J-62, J-130, J-134, J-137 thru J-138)

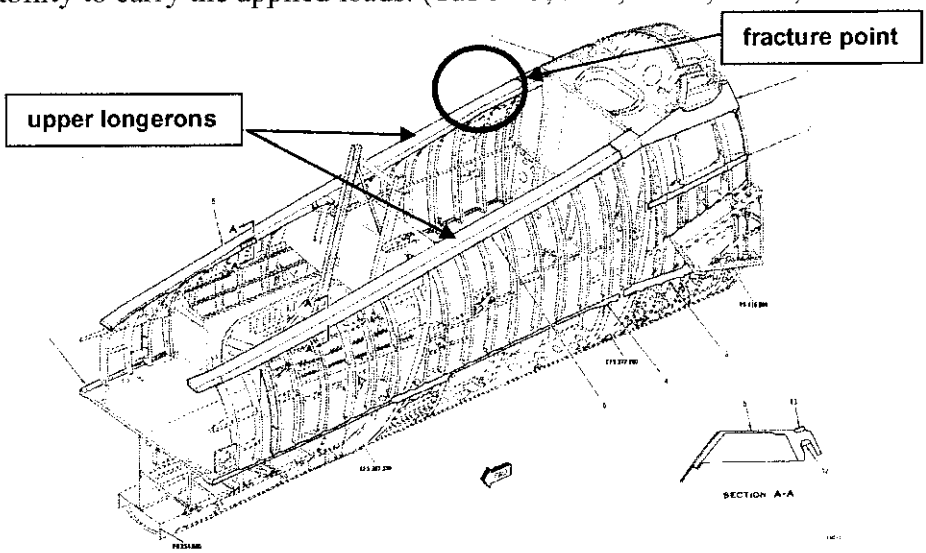
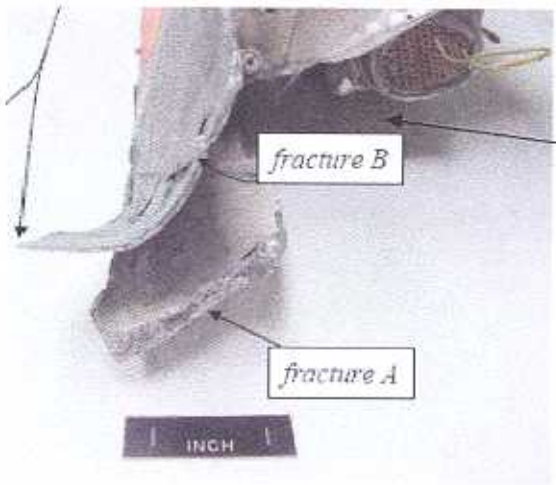


Figure B, Location of fuselage longeron failure in CFS 377.

Boeing and AFRL laboratory surface fracture analyses identified a fatigue crack with multiple origins in the upper web of the MA longeron. The fatigue crack progressed both inboard and outboard through the web. As the crack continued to grow through the inboard flange of the

longeron, the crack eventually led to overload failure of the remaining longeron section. (Tab J-33 thru J-38, J-61 thru J-62, J-138 thru J-139)



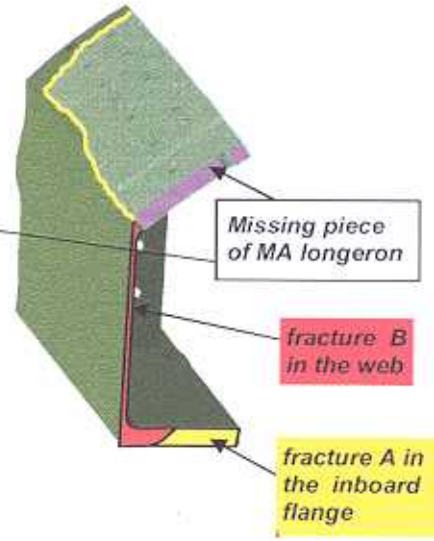


Figure C, MA's damaged upper right longeron. Figure D, Graphic depiction of failed longeron.
(Longerons above are lying on the inboard flange)

Boeing Finite Element Model (FEM) analysis demonstrates failure of the longeron in the CFS 377 bulkhead leads to catastrophic failure of the remaining forward fuselage structure. (Tab J-37, J-38, J-135) Dimensional analysis of the MA longeron in the 377 CFS area indicated the crack initiated in a thin section of the web measuring 0.039 to 0.073 inches. (Tab J-36, J-60, J-132) The blueprint thickness requirement for the web is a minimum of 0.090 inches. (Tab J-60) The MA web thickness did not meet blueprint specifications. (Tab J-60)

7. WEATHER

a. Forecast Weather

The forecast weather at Lambert IAP, MO for the mishap mission was clear skies, 10 nautical miles visibility and calm winds. Winds were forecast 5 knots out of the south at the time of take off. (Tab F-3 thru F-8)

b. Observed Weather

Observed weather at Lambert IAP, MO was clear skies, 9 miles visibility, calm winds, and the altimeter setting was 30.28 inches. The weather in the Lindbergh MOA was clear skies, westerly winds 15 to 25 knots. (Tab F-15 thru F-16, V-4.4)

c. Space Environment

Not applicable.

d. Conclusions

The mission was flown in accordance with weather requirements set forth in AFI 11-202, Vol. 3, *General Flight Rules*, 5 April 2006 and AFI 11-214, *Air Operations Rules and Procedure,* updated 11 April 2007. Weather was not a factor in this mishap.

8. CREW QUALIFICATIONS

The MP was a qualified mission ready, flight lead in the F-15A-D model aircraft. (Tab G-19) At the time of the accident, all necessary flight currencies were up-to-date and all required training for the planned mission was current pursuant to AFI 11-2F-15 Vol. 1, *F-15 Aircrew Training,* published on 9 January 2007. The MP performed his last mission evaluation on 14 April 2007, and his last instrument/qualification evaluation on 10 August 2007. He was rated qualified with no discrepancies noted on either evaluation. (Tab G-31 thru G-41) The following items were out of currency but had no impact on the mission: formation takeoff and formation landing. (Tab G-24)

9. MEDICAL

a. Qualifications

The MP's annual flight physical dated 7 September 2006 indicated he was qualified for worldwide military duty and fully medically qualified for flight duty. (Tab O-4, O-11) Additionally, the remaining mishap flight pilots (MF) and the maintenance crew members were medically qualified for duty at the time of the mishap. (Tab O-3 thru O-12)

b. Health

The AIB medical advisor reviewed the MP's medical and dental records in addition to his 72-hour and 14-day history reports. The records indicate the MP was in good health; his records did not show any recent performance-limiting injuries or illnesses prior to the mishap. (Tab O-4, O-11) According to medical records, the remaining MF and maintenance members were in good health prior to the mishap.

The MP successfully ejected from the aircraft at an altitude of approximately 18,000 ft MSL and minimized his injuries by directing his parachute to a clearing. (Tab V-1.17) According to the MP's testimony, he injured his arm and shoulder during the aircraft break up just prior to the ejection sequence. (Tab V-1.14 thru V-1.16) Review of the available evidence suggests that as the canopy forcefully detached from the aircraft it struck the MP in the upper left arm and shoulder. (Tab H-4 thru H-5)

The MP sustained a comminuted fracture (bone shatter fracture) dislocation of the left humerus, as a result of substantial blunt force trauma to his left upper arm. (Tab O-22) According to his interview, this injury prevented the MP from pulling the ejection seat handle with his left hand. (Tab V-1.15) After ejecting and parachuting to the ground, the MP complained of neck and back pain in addition to his left shoulder and arm injury. (Tab V-1.21) Evaluation at Barnes Jewish

Hospital confirmed the MP's arm and shoulder injury, but no additional significant injuries were identified. (Tab O-22)

c. Toxicology

Immediately following the mishap, in accordance with AFI 91-204, *Safety Investigations and Reports*, published on 14 February 2006, the commander directed toxicology testing for all personnel involved in the flight and the launch of the MA. Blood and urine samples were submitted to the Armed Forces Institute of Pathology (AFIP) for toxicological analysis. These tests are used to identify carbon monoxide and ethanol levels in blood and to detect traces of drugs in urine. Carbon monoxide testing was not accomplished on the MP because a preservative used to prevent blood from clotting was not added to the sample and made the specimen unsuitable for carbon monoxide testing. (Tab O-15) Testing revealed that carboxyhemoglobin saturations in the remaining MF and MA maintenance members were normal. (Tab O-13 thru O-14, O-16 thru O-21)

AFIP examined serum for the presence of ethanol at a cutoff of twenty milligrams per a deciliter. AFIP detected no ethanol in the MP's serum. (Tab O-15) Ethanol results were also negative for the MF and MA maintenance members. (Tab O-13 thru O-14, O-16 thru O-21)

Furthermore, AFIP screened the MF and MA maintenance members' urine for amphetamine, barbiturates, benzodiazepines, cannabinoids, cocaine, opiates and phencyclidine by immunoassay or chromatography. AFIP detected none of these drugs in the MP, MF or MA maintenance members. (Tab O-13 thru O-21)

d. Lifestyle

There is no evidence of unusual habits, behavior or stress on the part of the MP, MF or MA maintenance members that contributed to this accident.

e. Crew Rest and Crew Duty Time

Air Force Instructions require pilots have proper "crew rest," prior to performing in-flight duties. AFI 11-202, Volume 3, *General Flight Rules*, published on 5 April 2006, defines normal crew rest as a minimum of a 12-hour non-duty period before the designated flight duty period (FDP). During crew rest, an aircrew member may participate in meals, transportation or rest as long as he or she has the opportunity for at least eight hours of uninterrupted sleep.

A review of the MP and MFL's duty cycles leading up to the mishap indicates both pilots had adequate crew rest in accordance with AFI 11-202. The MP's last flight prior to the mishap occurred on 11 October 2007 and the MFL's last flight before the mishap was on 31 October 2007. (Tab G-14, G-22) Additionally, the MP and MFL complied with the crew rest and duty day requirements for 2 November 2007. Neither the MP nor the MFL suffered from stress, pressure, fatigue or lack of rest prior to or during the mishap sortie.

10. OPERATIONS AND SUPERVISION

a. Operations

The MP is a current and qualified F-15 pilot with nearly 1,400 hours of flight time in the F-15. (Tab G-5 thru G-16, G-21) The MFL is a current and qualified F-15 instructor pilot (IP) and F-15 flight examiner in accordance with AFI 11-202 Vol. 2, *Aircrew Standardization/Evaluation Program,* published on 19 September 2007. Additionally, the MFL has over 3,500 hours of flight time in the F-15. (Tab G-17 thru G-21)

b. Supervision

The 110 FS operations supervisor ensured the MF was current and qualified for the BFM training mission. (Tab G-23, G-24) The MFL, who was also the squadron commander, provided the preflight briefing for the MF. (Tab V-1.6) The operations supervisor on 2 November 2007 was a current and qualified 4-ship flight lead and flight commander. (Tab G-20) He provided a standard briefing to the Mick flight (Tab V-1.7) in accordance with, AFI 11-418, *Operations Supervision*, published on 20 March 2007. There are no operations or supervision issues relevant to the mishap.

11. HUMAN FACTORS

Human error is the single greatest mishap hazard. It is identified as a causal factor in 80-90 percent of mishaps and is present but not causal in 50-60 percent of all mishaps. A human factor is any environmental factor or individual psychological factor a human being experiences that contributes to or influences his performance during a task.

The Department of Defense Human Factors Analysis and Classification System utilizes a four tier model in order to systematically assess the myriad of potential human factors that may or may not be relevant to an accident investigation. These four main tiers of failures/conditions are: Acts, Preconditions, Supervision, and Organizational Influences. The human factor model examines these tiers from three perspectives: Cognitive Viewpoint and Human System Interaction and Integration, Human to Human Interaction, and Sociocultural and Organization. (Tab BB-6)

MP acts, Preconditions, Supervisory and Organizational Influences were not factors in this mishap event. The MP's actions during the mishap sequence were focused, precise and appropriate; his actions did not contribute to the mishap. The MA maintenance personnel were well-trained, experienced and qualified. A through review of maintenance procedures and records indicate neither errors nor adverse trends contributed to the accident.

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Primary Operations Directives and Publications

1. Air Force Instruction (AFI) 11-2F-15, Volume 1, *F-15--Aircrew Training*, 19 July 2004
2. AFI 11-2F-15, Volume 2, *F-15--Aircrew Evaluation Criteria*, 3 February 2004
3. AFI 11-2F-15, Volume 3, *F-15--Operations Procedures*, 21 July 2004
4. AFI 11-202, Volume 1, *Aircrew Training*, 23 November 2005
5. AFI 11-202, Volume 2, *Aircrew Standardization/Evaluation Program*, 17 June 2002
6. AFI 11-202, Volume 3, *General Flight Rules*, 16 February 2005
7. AFI 11-214, *Air Operations Rules and Procedures*, 22 December 2005
8. AFI 11-301, Volume 1, *Aircrew Life Support (ALS) Program*, 19 July 2002
9. AFI 11-401, *Aviation Management*, 15 December 2004
10. AFI 11-403, *Aerospace Physiological Training Program*, 20 February 2001
11. AFI 11-418, *Operations Supervision*, 21 October 2005
12. AFI 11-421, *Aviation Resource Management*, 1 November 2004
13. AFI 51-503, *Aerospace Accident Investigations*, 16 July 2004
14. AFI 91-204, *Safety Investigations and Reports*, 14 February 2006
15. Technical Order (T.O.) 1F-15A-1, *Flight Manual, USAF Series F-15A/B/C/D Aircraft Block 7 and Up*, 15 November 2000 with Change 13 dated 1 June 2005

b. Maintenance Directives and Publications

1. AFI 21-101, *Aerospace Equipment Maintenance Management*, 1 June 2004
2. AFI 21-124, *Oil Analysis Program*, 4 April 2003
3. T.O. 00-20-1, *Aerospace Equipment Maintenance Inspection, Documentation, Policies and Procedures*, 30 April 2003 with Change 3 dated 31 May 2005
4. T.O. 33-1-37, *Joint Oil Analysis Program Laboratory Manual, Volume I*, 1 July 2005 with Change 4 dated 7 December 2005, *Volume II*, 1 July 2005 with Change 4 dated 7 December 2005, *and Volume III*, 1 December 2004 with Change 37 dated 7 December 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

There are no known or suspected deviations from directives or publications by crew members or others involved in the mishap mission.

13. NEWS MEDIA INVOLVEMENT

a. Initial Queries and Reports.

According to the MoANG public affairs officer, initial media interest related to the mishap was moderate. Reporters from local television stations covered the mishap. Written media, both

national and international, also covered the mishap. Samples of media coverage retrieved from the worldwide web are attached at Tab DD.

b. Media Visits to the Crash Site.

A privately owned news helicopter flew in the airspace and recorded the mishap site shortly after the mishap.

c. Subsequent Media Interest.

Media interest has been very high regarding the mishap's impact on the F-15 fleet. Examples of this coverage are included at Tab DD.

14. ADDITIONAL AREAS OF CONCERN

No additional areas of concern contributed to this aircraft accident.

WILLIAM WIGNALL, Colonel, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

F-15C, T/N 80-0034 ACCIDENT
2 November 2007

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 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

As a result of the investigative process, I find, by clear and convincing evidence, the cause of this accident was the failure of the upper right longeron, a critical support structure in the F-15C aircraft, because the longeron failed to meet blueprint specifications. Engineering and metallurgy analysis of the recovered mishap aircraft (MA) wreckage identified a fatigue crack in the thin web of the longeron near canted fuselage station (CFS) 377 which grew under cyclical flight loads and ultimately led to longeron failure. The longeron failure subsequently triggered a catastrophic failure of the remaining support structures and caused the aircraft to break apart in-flight. These findings are supported by witness interviews, technical analyses results, examination of relevant documents, and the review of in-flight recorded data.

2. DISCUSSION OF OPINION

a. Overall Considerations

Based on interviews, training records and aircraft documentation, operations, supervision, mission planning, briefing, preflight, and flight operations associated with the accident did not cause the mishap event. All maintenance supervision records, MA Maintenance reports, unscheduled maintenance documentation, aircraft inspection reports, and policies were in good order and in compliance with applicable instructions. Furthermore, witness interviews and documentation confirmed weather conditions, pilot qualifications and flight supervision did not contribute to the mishap. After reviewing applicable medical histories, toxicology tests and witness interviews, human error was eliminated as a possible mishap factor. As a result, the accident investigation board focused its investigation and analysis on the structures of the aircraft surrounding the area of the aircraft break-up.

b. Engineering Analysis

Material engineers from Boeing Aircraft Company (Boeing) and the Air Force Research Laboratory inspected and analyzed several critical structural components from the MA and discovered a structural flaw in the MA's upper right longeron - a fatigue crack with multiple

origins present in the web of the upper right longeron immediately forward of CFS 377. The crack grew through the inboard flange until overload failure of the remaining longeron section occurred. Boeing's finite element modeling confirmed a failure of the longeron in this area would be catastrophic and lead to complete failure of the remaining structure and aircraft break-up.

AFRL material engineers found the longeron web thickness in the MA did not meet blueprint specification. In this case, the MA longeron's failure to meet blueprint specification increased localized stress in the thin web and led to crack initiation. The crack grew undetected and led to catastrophic failure of the MA. Prior to the mishap event, no inspection criteria existed to inspect the longerons in the forward fuselage. Inspection criteria for the forward fuselage were never developed because during initial fatigue testing on the aircraft, no fatigue failures or cracks were detected in the forward fuselage structures.

WILLIAM WIGNALL, Colonel, USAF
President, Accident Investigation Board