UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION
BOARD REPORT

F-16CM, T/N 92-3883

13TH FIGHTER SQUADRON
35TH FIGHTER WING
MISAWA AIR BASE, JAPAN

LOCATION: MISAWA AIR BASE, JAPAN

DATE OF ACCIDENT: 20 FEBRUARY 2018

BOARD PRESIDENT: COLONEL SERGIO J. VEGA

Conducted IAW Air Force Instruction 51-503

EXECUTIVE SUMMARY

AIRCRAFT ACCIDENT INVESTIGATION
F-16CM, T/N 92-3883
MISAWA AIR BASE, JAPAN
20 FEBRUARY 2018

On 20 February 2018, at 0838L, an F-16CM, tail number (T/N) 92-3883, during departure at Misawa Air Base (AB), Japan, experienced an engine fire on takeoff during a routine training sortie, necessitating an immediate landing back at Misawa AB. The mishap aircraft (MA) was based at Misawa AB, Japan, and assigned to the 13th Fighter Squadron, of the 35th Fighter Wing. The MA sustained engine damage and loss of external fuel tanks with an estimated governmental loss of $987,545.57.

The mishap flight (MF) consisted of two F-16CM aircraft. The mishap flight's pre-flight, start, and taxi were uneventful until the departure phase of flight. The mishap pilot (MP) departed runway (RWY) 28, fifteen seconds after the mishap lead pilot (MLP). Shortly after the afterburner takeoff, Misawa air traffic controllers informed the MP and the mishap lead pilot (MLP) that the MP had a large flame coming from the aft section of the MP's aircraft. The MLP also contacted the MP regarding the fire. During the MP's ascent, he noticed an unexpected decay in his airspeed and climb rate. The MP took a right turn back towards RWY 28, and when unable to maintain airspeed or altitude, the MP jettisoned his stores (external fuel tanks) in accordance with F-16CM critical actions procedures. Following the jettison, the MA regained some airspeed and achieved a better climb rate to get into a position to land. The MP landed on RWY 28, and accomplished the emergency engine shutdown and emergency ground egress critical action procedures. There were no injuries resulting from the mishap. The MP's actions during the mishap sequence were focused, precise, and appropriate; his actions did not contribute to the mishap. A review of maintenance procedures revealed several past actions that were causal to the accident.

The AIB President found by a preponderance of the evidence that the cause of the accident was an obsolete part that fractured, causing the engine to overheat. In 2012, maintenance personnel ordered and installed an obsolete part, a turbine frame forward fairing, years after it was replaced by a forward fairing made of stronger material and design. The logistics system then delivered the obsolete forward fairing. Maintenance personnel installed the obsolete forward fairing on the mishap engine (ME) using the updated version of the bracket hardware. The obsolete forward fairing's weaker material, along with wear from the mismatched hardware, ultimately caused the forward fairing to fracture during takeoff. Once fractured, a piece of the forward fairing lifted and blocked the cooling flow of air around the engine, causing the area near the blockage to overheat and catch fire. The AIB President further found by a preponderance of the evidence that maintenance practices during the 2012-2015 timeframe substantially contributed to the mishap.

SUMMARY OF FACTS AND STATEMENT OF OPINION
F-16CM, T/N 92-3883
20 FEBRUARY 2018

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ACRONYMS AND ABBREVIATIONS

AB	Air Base
ACES	Advanced Concept Ejection Seat
ACN	Aircraft Classification Number
AF	Air Force
AFB	Air Force Base
AFCEC	Air Force Civil Engineer Center
AFE	Aircrew Flight Equipment
AFECT	Aircrew Flight Equipment Continuation Training
AFI	Air Force Instruction
AFIP	Air Force Institute of Pathology
AFLCMC	Air Force Life Management Center
AFMES	Air Force Medical Examiner System
AFPAM	Air Force Pamphlet
AFSC	Air Force Specialty Code
AFSEC	Air Force Safety Center
AFTO	Air Force Technical Order
AGL	Above Ground Level
AIB	Accident Investigation Board
AIM	Air Intercept Missile
AMU	Aircraft Maintenance Unit
AMXS	Aircraft Maintenance Squadron
AOA	Angle of Attack
AUX	Auxiliary
BP	Board President
CAF	Combat Air Force
CANN	Cannibalization
Capt	Captain
CC	Commander
CDI	Command Directed Investigation
CE	Civil Engineer
CEMS	Comprehensive Engine Management System
CERF	Central Engine Repair Facility
CES/CEIE	Civil Engineer Squadron, Environmental Element
CG	Center of Gravity
CIM	Chief of Installation Management
CMSgt	Chief Master Sergeant
Col	Colonel
COMPACAF	PACAF Commander
COSO	Combat Oriented Supply Organization
CPI	Continuous Process Improvement
CRF	Centralized Repair Facility
CSFDR	Crash Survivable Flight Data Recorder
CSMU	Crash Survivable Memory Unit
CTH	Consolidated Track History
D&I	Drill and Instruction
DLA	Defense Logistics Agency
DMS	Decentralized Maintenance Support
DoD	Department of Defense
DODAC	Department of Defense Activity Code
DRMO	Defense Reutilization Management Office
DU	Display Unit
EDNA	Enhanced Diagnostics Aid
EFH	Engine Flight Hours
DIFM	Due In For Maintenance
EMB	Engine Management Branch
EOF	End Of Flight
EPS	Emergency Power System or Supply
ESS	Enterprise Supply System
ETID	Electronic Turn In Document
FCIF	Flight Crew Information File
FERMS	Flight Equipment Records Management System
FHR	Flight Hours
FLCS	Flight Control System
FOM	Facilitation Other Maintenance
FP	Flight Profile
FPM	Feet Per Minute
FS	Fighter Squadron
FSC	Flight Service Center
FTIT	Fan Turbine Inlet Temperature
FW	Fighter Wing
GE	General Electric
GPS	Global Positioning System
GS	General Schedule
HUD	Heads-Up Display
Hz	Hertz

IAW In Accordance With
IFR Instrument Flight Rules
IFT In Flight Time
IG Inspector General
IMDS Integrated Maintenance Data System
IO Investigating Officer
IP Instructor Pilot
IPB Illustrated Parts Breakdown
ISB Interim Safety Board
JEIM Jet Engine Intermediate Maintenance
JMSDF Japanese Maritime Self-Defense Force
JOAP Joint Oil Analysis Program
JP-8 Jet Propellant 8
K Thousand
KCAS Knots Calibrated Airspeed
KTAS Knots True Airspeed
KTL Key Task Listing
kts Knots
L Local Time
LA Legal Advisor
Lt Col Lieutenant Colonel
LPT Low Pressure Turbine
LRS Logistics Readiness Squadron
MA Mishap Aircraft
Maj Major
MAJCOM Major Command
ME Mishap Engine
MDG Medical Group
MF Mishap Flight
MFL Mishap Flight Lead
MFL Maintenance Fault List
MICAP Mission Impair Capability Awaiting Parts
MLC Master Labor Contract
MLG Main Landing Gear
MLITT Ministry of Land, Infrastructure, Transport and Tourism
MLP Mishap Lead Pilot
MM Mishap Mission
MOD Ministry of Defense
MOF Maintenance Operations Flight
MP Mishap Pilot
MPC Mission Planning Cell
MQT Mission Qualification Training
MS Mishap Sortie
MSgt Master Sergeant
MSL Mean Sea Level
MUNS Munitions Squadron
MXS Maintenance Squadron
MXG Maintenance Group
MXM Maintenance Member
MXS Maintenance Squadron
NAF Numbered Air Force
NCOIC Noncommissioned Officer In Charge
NM Nautical Miles
NOTAMs Notices to Airmen
NSN National Stock Number
OG Operations Group
OGV OG Standardization/Evaluation
Ops Tempo Operations Tempo
ORM Operational Risk Management
OSK Weapons and Tactics
OSS Operation Support Squadron
PA Public Affairs
PACAF Pacific Air Forces
PEX Patriot Excalibur
PFL Pilot Fault List
PM Pilot Member
PPD Physical Property Data
PR/BPO Combined Preflight/Basic Post Flight
PR Preflight
QA Quality Assurance
QRL Quick Reference List
QVI Quality Verification Inspection
REC Recorder
RIE Rapid Improvement Events
ROS Report of Survey
RTB Return-To-Base
RWY Runway
SARM Squadron Aviator Resource Manager
SARSAT Search and Rescue Satellite
SBAFE SIB Flight Equipment Member
SBAFSEC SIB AFSEC Member
SBFS SIB Flight Surgeon
SBMX SIB Maintenance Member
SBP SIB Pilot Member
SBREC SIB Recorder
SEAD Suppression of Enemy Air Defense
SIB Safety Investigation Board

SLEP	Service Life Enhancement Program
SMSgt	Senior Master Sergeant
SOF	Supervisor of Flying
SP	SIB President
SPO	System Program Office
SrA	Senior Airman
TCTO	Time Compliance Technical Order
TDB	Tohoku Defense Bureau
TMO	Traffic Management Office
T/N	Tail Number
TNB	Tail Number Bin
TO	Technical Order
TODA	Technical Order Distribution Agents
TODO	Technical Order Distribution Officer
TSgt	Technical Sergeant
USFJ	United States Forces Japan
VMC	Visual Meteorological Conditions
VFR	Visual Flight Rules
VSV	Variable Stator Vane
WAI	Walk Around Inspection
WCE	Work Center Event
WRE	War Reserve Equipment
WX	Flight Visibility and Weather
XB3	Expendable Item
XD2	Expendable at Depot Level
XF3	Expendable At Intermediate Level
1LT	First Lieutenant

SUMMARY OF FACTS

1. AUTHORITY AND PURPOSE

a. Authority

On 1 March 2018, Major General Russell L. Mack, Vice Commander, Pacific Air Forces (PACAF), appointed Colonel Sergio J. Vega to conduct an aircraft accident investigation for a mishap that occurred on 20 February 2018 involving an F-16CM aircraft, tail number (T/N) 92-3883, at Misawa Air Base (AB), Japan. (Tab Y-1) The investigation was conducted at Misawa AB, Japan, from 26 March 2018 through 20 April 2018. The following board members were appointed: a Captain (Capt) Legal Advisor (LA), a First Lieutenant (1LT) Pilot Member (PM), A Master Sergeant (MSgt) Maintenance Member (MXM), and a Technical Sergeant (TSgt) Recorder (REC). (Tab Y-1 to Y-2)

b. Purpose

In accordance with AFI 51-503, *Aerospace and Ground Accident Investigations*, this accident investigation board conducted a legal investigation to inquire into all the facts and circumstances surrounding this Air Force aerospace accident, prepare a publicly releasable report, and obtain and preserve all available evidence for use in litigation, claims, disciplinary action, and adverse administrative action.

2. ACCIDENT SUMMARY

The mishap aircraft (MA), an F-16CM, T/N 92-3883, assigned to the 13th Fighter Squadron located at Misawa AB, Japan, flown by the mishap pilot (MP), departed and landed at Misawa AB on 20 February 2018. (Tab K-3, CC-71) The MP experienced an engine fire on takeoff during a routine training sortie, necessitating an immediate landing. (Tab J-2) The MP jettisoned his fuel tanks in accordance with the F-16 flight crew checklist. (Tab V-17.14) There were no injuries; the mishap engine (ME) was impounded. Damage to the MA totaled $987,545.57. (Tab P-3)

3. BACKGROUND

The MA was assigned to the 13th Fighter Squadron (13 FS) located at Misawa AB, Japan. The 13 FS falls directly under the 35th Operations Group (35 OG), which falls under the 35th Fighter Wing (35 FW), and 5th Air Force (5 AF). (Tab CC-2 to CC-11) 5 AF is a Numbered Air Force (NAF) within Pacific Air Force (PACAF). (Tab CC-2 to CC-11)

a. Pacific Air Forces (PACAF)

PACAF's primary mission is to provide ready air and space power to promote U.S. interests in the Asia-Pacific region during peacetime, through crisis, and in war. (Tab CC-2) PACAF's area of responsibility is home to 60 percent of the world's population in 36 nations spread across 52 percent of the Earth's surface and 16 time zones, with more than 1,000 languages spoken. (Tab CC-2) PACAF maintains a forward presence to help ensure stability in the region. (Tab CC-2)

The command has approximately 320 fighter and attack aircraft and 46,000 military and civilian personnel serving in nine major locations and numerous smaller facilities, primarily in Hawaii, Alaska, Japan, Guam and the Republic of Korea. (Tab CC-2)

b. Fifth Air Force (5 AF)

5 AF's mission is three-fold. First, 5 AF plans, conducts, controls, and coordinates air operations in accordance with tasks assigned by the PACAF Commander. Secondly, 5 AF maintains a level of readiness necessary for successful completion of directed military operations. Third and finally, 5 AF assists in the mutual defense of Japan and enhances regional stability by planning, exercising, and executing joint air operations in partnership with Japan. To achieve this mission, 5 AF maintains its deterrent force posture to protect both U.S. and Japanese interests, and conducts appropriate air operations should deterrence fail. (Tab CC-3)

c. 35th Fighter Wing (35 FW)

The 35 FW, headquartered at Misawa AB, Japan, provides worldwide deployable forces, protects U.S. interests in the Pacific, and defends Japan with sustained forward presence and focused mission support. (Tab CC-4) The wing operates and maintains two squadrons of F-16CM (C and D models) Block 50 Fighting Falcons. (Tab CC-4) The 35 FW is the Air Force's premier Wild Weasel organization and specializes in the supression and destruction of enemy air defenses including surface-to-air-missile systems. (Tab CC-4)

d. 35th Operations Group (35 OG)

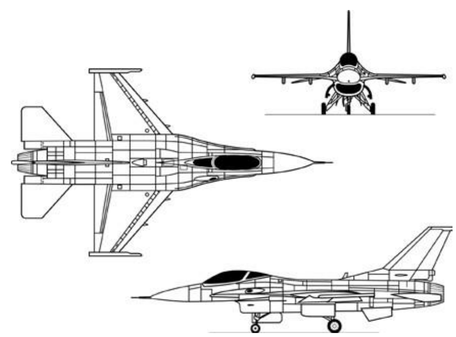
The 35 OG is a component of the 35 FW, Misawa AB, Japan. It is a combat-ready fighter group of two deployable F-16CM "Wild Weasel" fighter squadrons, one operational support squadron, and one air control flight capable of conducting and supporting air operations worldwide. The 35 OG is responsible for flight operations, airfield management, intelligence, tactical air control, combat plans, weapons and tactics, and weather support to the 35 FW. (Tab CC-7)

e. 13th Fighter Squadron (13 FS)

The mission of the 13 FS is to provide Suppression of Enemy Air Defenses (SEAD) combat airpower to the combatant commanders. (Tab CC-10) During its distinguished 76-year history, the 13 FS has flown 8 different types of aircraft, received 21 unit citations, and accumulated 20 campaign streamers. (Tab CC-10)

f. The F-16 Fighting Falcon

The F-16 Fighting Falcon is a compact, multi-role fighter aircraft. It is highly maneuverable and has proven itself in air-to-air combat and air-to-surface attack. It provides a relatively low-cost, high-performance weapon system for the United States and allied nations. (Tab CC-12) Since 11 September 2001, the F-16 has been a major component of the combat forces flying thousands of sorties in support of Operations Noble Eagle (Homeland Defense), Enduring Freedom in Afghanistan, and Iraqi Freedom. (Tab CC-12)



4. SEQUENCE OF EVENTS

a. Mission

The mishap mission (MM) was planned and briefed without incident and had a valid flight authorization. (Tab K-2, Tab V-17.11). The MM involved two F-16CM aircraft. (Tab AA-2)

b. Planning

Flight products for the MM were produced the day of the flight by the MP before the mass briefing. (Tab V-17.11) Prior to the MM, all flight members attended a mass briefing conducted by the squadron operations supervisor. (Tab V-17.13) The mass briefing adequately covered forecasted weather conditions, notices to airmen (NOTAMs), and other routine items. (Tab V-17.13) The mishap lead pilot (MLP), the pilot in charge of the formation, also conducted a coordination brief and a tactical brief for the MM. (Tab V-2.1)

c. Preflight

After the flight briefings, the personnel involved in the MM assembled at the 13 FS operations desk and received an update from the operations supervisor prior to proceeding to their assigned aircraft. (Tab V-17.13) During this brief, the operations supervisor provided updated information on items pertinent to flying that day and assigned them their aircraft. (Tab V-17.13) The MP noted no discrepancies upon inspection of his aircrew flight equipment. (Tab V-17.13) The MP's preflight inspection, engine start procedures, and ground operations were uneventful. (Tab V-17.13, V-2.1)

d. Summary of Accident

Mishap Flight Summary:

The MP reported no issues during taxi. (Tab V-17.20) The MP took off at 0838L in afterburner, fifteen seconds behind the MLP. (Tab J-2, Tab V-2.1) Shortly after the MP became airborne, the tower controllers and the supervisor of flying noticed a large twenty to thirty-foot flame coming from the engine at the back of the MP's aircraft. (Tab V-4.1)

Upon seeing the flames, the tower controllers informed the MP of the fire. (Tab V-4.1) The MP did not hear this radio call, but the MLP did. (Tab V17.4, V-2.1) Upon hearing the radio call, the MLP made a right turn to rejoin with the MP and visually confirm the fire. (Tab N-2, V-2.1) The MLP then informed the MP of the fire and told the MP to make a right turn to a position where the MP could reach the runway and land if the engine failed, known as a key position. (Tab V-2.2) At this point, the MP acknowledged the MLP's statements and began to ascend to a key position. (Tab N-2, V-2.2) During the ascent, the MP was only able to gain a fraction of the airspeed that he typically could have gained. **Figure 1** (Tab U-5, U-6)

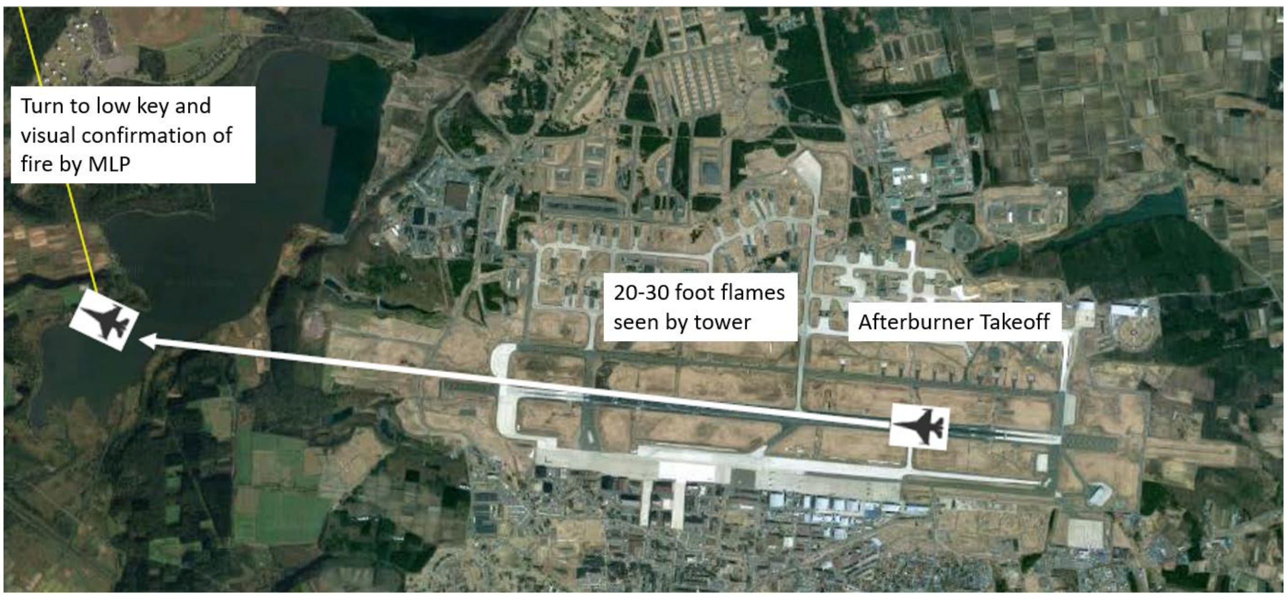


Figure 1: Mishap Aircraft Mishap Timeline (Tab Z-31)

In trying to reach a key position, the MP started a right turn back towards the runway, and was able to achieve the minimum controlled ejection altitude of two-thousand feet above ground level. (Tab U-5) During this turn, the MP, unable to retain his airspeed or gain sufficient altitude, decided he needed to emergency jettison his external fuel tanks. (Tab V-17.8) Before jettisoning his fuel tanks, the MP checked the area below to ensure it was uninhabited. (Tab V-17.8) After confirming he was over an uninhabited area, the MP jettisoned his fuel tanks, which impacted Lake Ogawara. (Tab V-17.8) This jettison was in accordance with the F-16 fire-in-flight critical action procedures and local area procedures. (Tab BB-21, V17.14) Jettisoning the external fuel tanks made the MA lighter, allowing the MP to gain airspeed and altitude, and require less distance for landing. (Tab U-6, U-7, U-8) The MLP observed the fuel tank jettison and electronically marked the point where the fuel tanks fell. (Tab V-2.2)

Figure 2: Mishap Aircraft Mishap Timeline (Tab Z-32)

After jettisoning his fuel tanks, the MP asked the MLP if there was still a fire. **Figure 2** (Tab N-3, V-17.10) The MLP replied that he still saw smoke trailing the MA. (Tab N-3) The MP then tested the fire/overheat light in the MA, ensuring that it was functioning properly. (Tab V-17.8)

The MP then scanned his engine instruments and noticed the engine nozzle reading was incorrect for his power setting. (Tab N-3, V-17.10) The MP communicated his nozzle reading to the MLP and asked the MLP if there was still a fire. (Tab N-3, V-17.10) The MLP stated that there were puffs of smoke still trailing the MA. (Tab N-3, Tab V-17.19) At this point, the MP assessed that he was no longer on fire. (Tab V-17.10) The MP reached a key position and accomplished a safe landing. (Tab V-17.11) He then stopped on the runway and accomplished the critical action procedures for both emergency shutdown and emergency ground egress. **Figure 3** (Tab V-17.11)

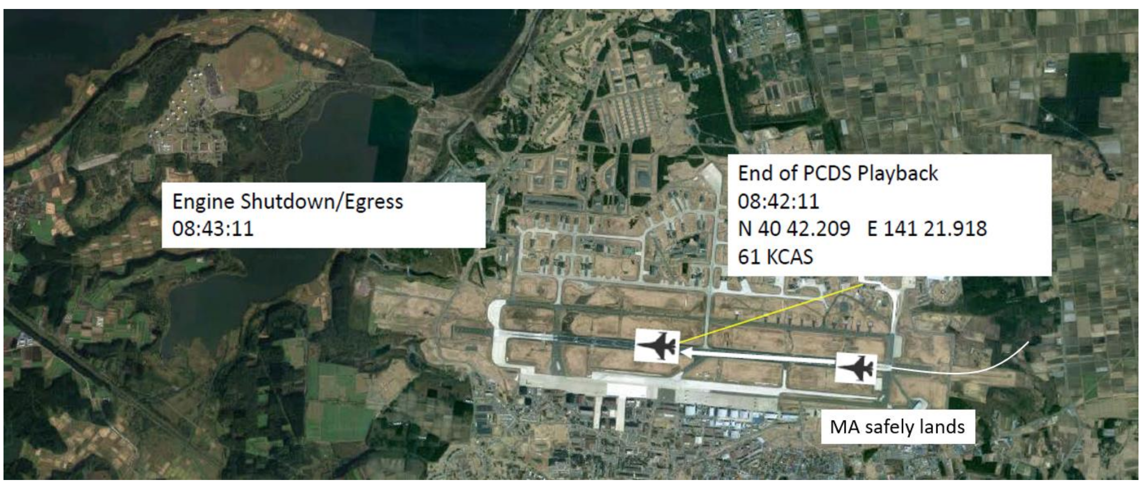


Figure 3: Mishap Aircraft Mishap Timeline (Tab Z-33)

Mishap Engine Summary:

The Mishap Engine (ME) is a General Electric (GE) F110129 with serial number GE0E538133 (538133). **Figure 4** shows a cross-sectional view of the F110129 engine, highlighting the major assemblies. (Tab CC-71)

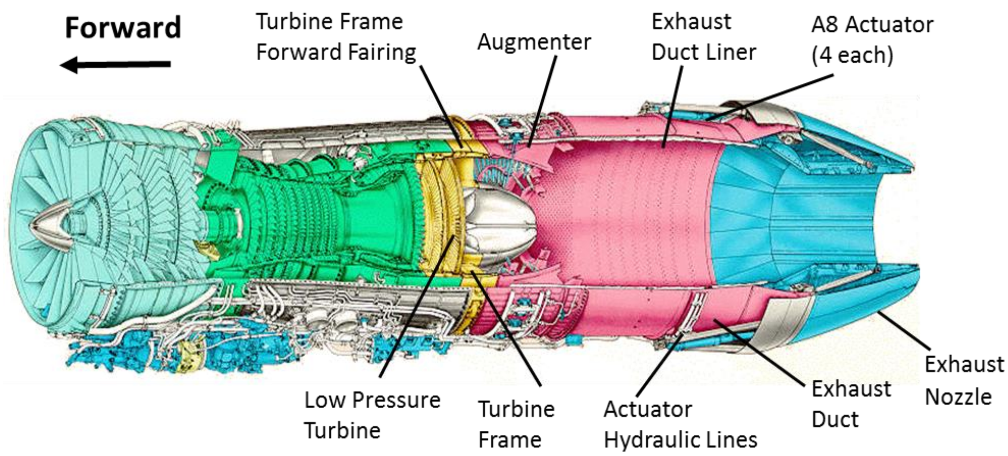


Figure 4: F110-129 Engine Schematic (Tab CC-63)

The cause of the mishap was an uncontained engine fire. (Tab CC-73) This fire was directly caused by the installation of an obsolete turbine frame forward fairing that was known to be susceptible to failure. (Tab CC-73) Specifically, in August 2007, safety Time Compliance Technical Order 2J-F110129-682 (TCTO-682) dictated replacement across the fleet by August 2010 of this susceptible fairing, along with its attaching hardware. (Tab CC-70, Tab CC-73) The susceptible fairing then became obsolete, as it was replaced with an updated fairing of improved material and design. (Tab CC-73) The fairing was made up of three titanium segments that connect, creating a ring that lines the forward outer section of the turbine frame. (Tab CC-79) While the redesign was still comprised of the three segments, wear brackets and sacrificial wear strips were added onto the fairing. (Tab CC-78) The redesign also included the use of a more durable material for the existing wear pads on the top and bottom of the fairing. (Tab CC-78)

The ME had the updated fairing properly installed in accordance with TCTO-682 on 03 June 2010. (Tab CC-73) However, the updated fairing was later re-replaced with an obsolete fairing during engine maintenance in 2012. (Tab CC-73) The updated wear brackets exacerbated wear into the fairing, ultimately leading the fairing to fracture during takeoff of the MA. (Tab CC-73) Portions of the fractured fairing then lifted into the cooling airstream of the engine, blocking essential cooling air to the exhaust nozzle liner and other downstream components. (Tab CC-73) Without the exhaust liner to contain the hot gases from the exhaust, the heat burned through the exhaust duct to the exterior of the engine causing a fire. (Tab CC-73) This fire caused extensive damage to the engine's rear components. (Tab CC-73)

Figure 5 from the ME shows a fractured fairing segment at the 4:30 position. (Tab CC-75) This fairing segment was missing one of its bolt heads and had lifted away from its normal position. (Tab CC-75) **Figure 6** shows another larger section of the fairing segment that fractured and lifted into the cooling air flowpath. (Tab CC-75)

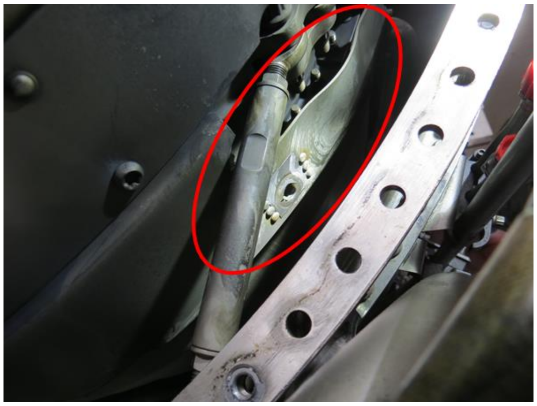


Figure 5: Turbine frame forward fairing with missing bolt at 4:30 position (Tab CC-75)

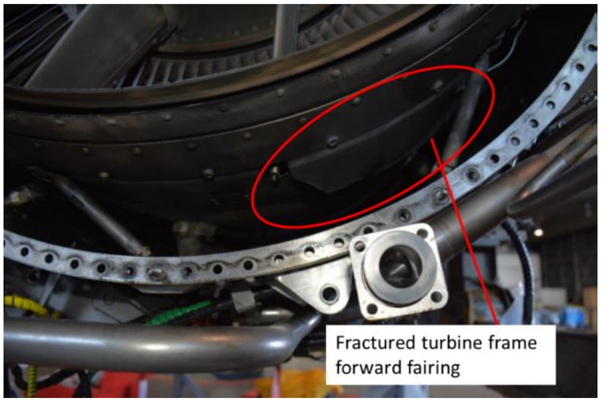


Figure 6: Turbine frame forward fairing damage at 5:30 position (Tab CC-75)

Removal of the forward fairing from the ME revealed wear from the updated mounting brackets that were installed underneath the turbine frame fairing. (Tab CC-75) In several locations, these brackets had worn completely through the fairing. (Tab CC-76) **Figures 7 and 8** show these wear areas on the fairing segments. (Tab CC-76)

Figure 7: Turbine frame fairing wear marks (Tab CC-76)

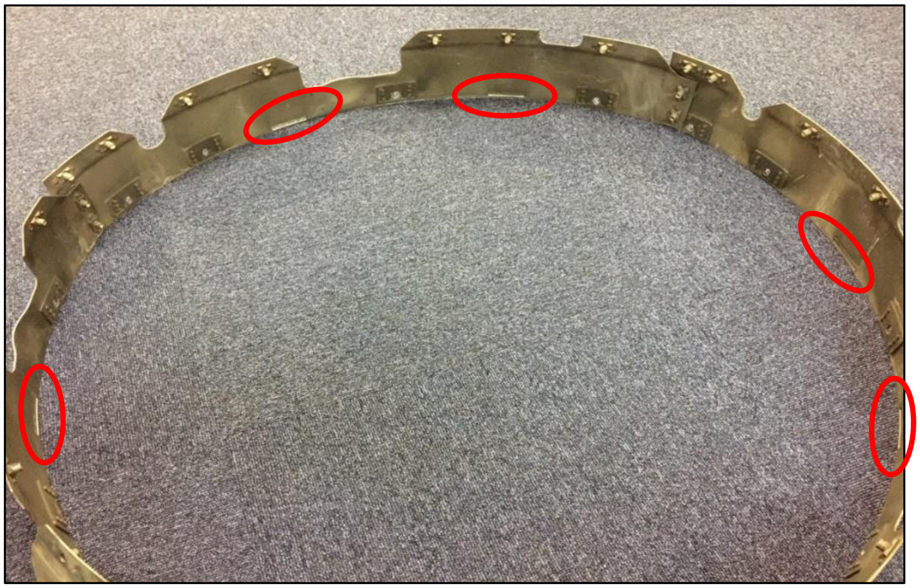


Figure 8: Turbine frame fairing wear marks (Tab Z-13)

Figures 9 and 10 show the fracturing that occurred as a result of the excessive wear on the fairing segments. (Tab CC-76) **Figure 9** is a fairing segment that fractured in two locations. (Tab CC-76)

Both fractures emanate from areas where the wear brackets had worn completely through the fairings. (Tab CC-76)

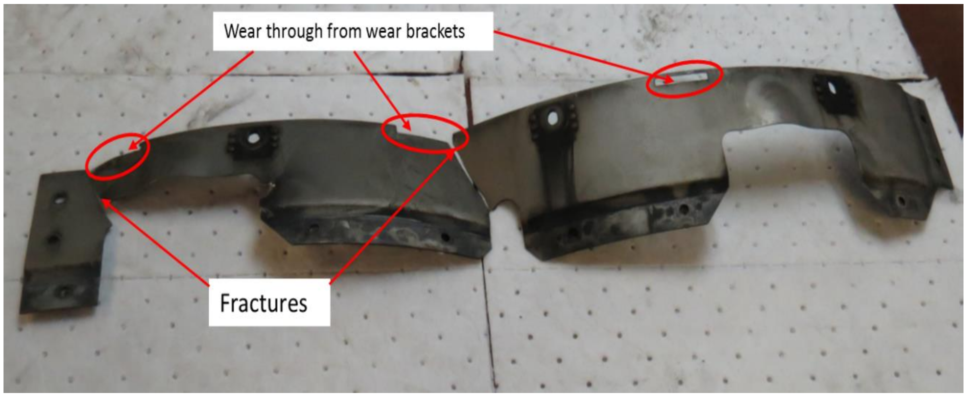


Figure 9: Fractures emanating from bracket wear (Tab CC-76)

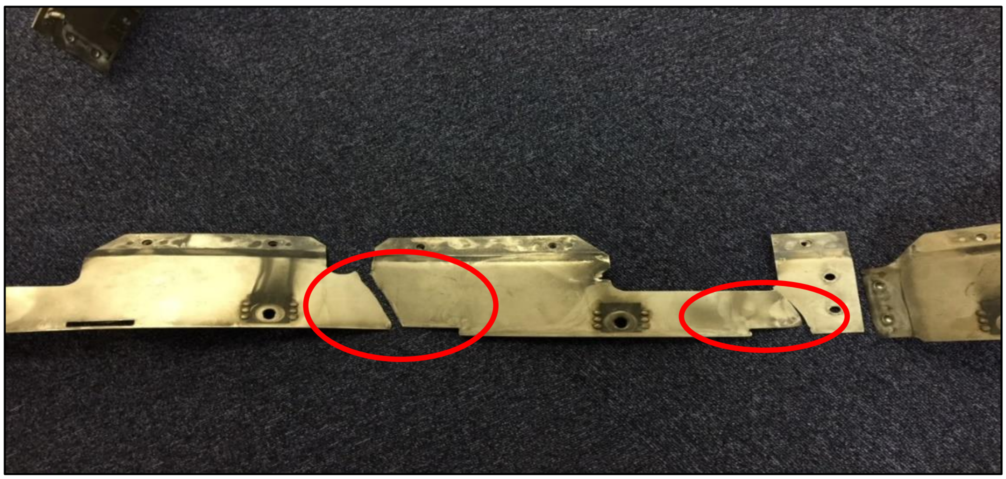


Figure 10: Fractures emanating from bracket wear (Tab Z-9)

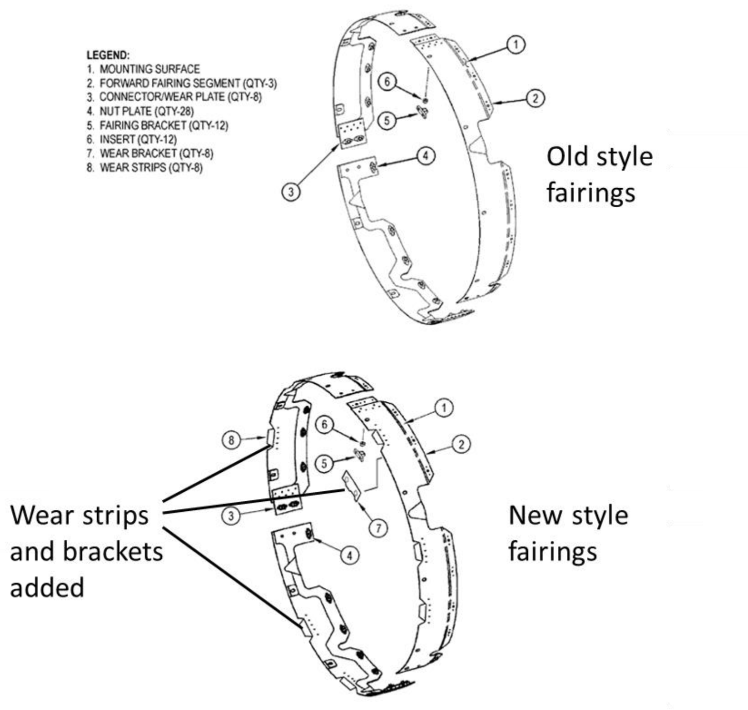


Figure 11: Fairing design change (Tab CC-79)

The absence of the wear strips on the obsolete fairing created a material mismatch between the relatively soft titanium fairing and the hardened composite material wear brackets. (Tab CC-71) This exacerbated the wear on the fairing and, in many areas, caused a complete wear-through at these contact points. (Tab CC-79)

Figure 12 and 13 show one of the wear brackets worn completely through the obsolete fairing on the ME. (Tab CC-79)

Figure 12: Forward fairing wear bracket worn through fairing (Tab CC-79)

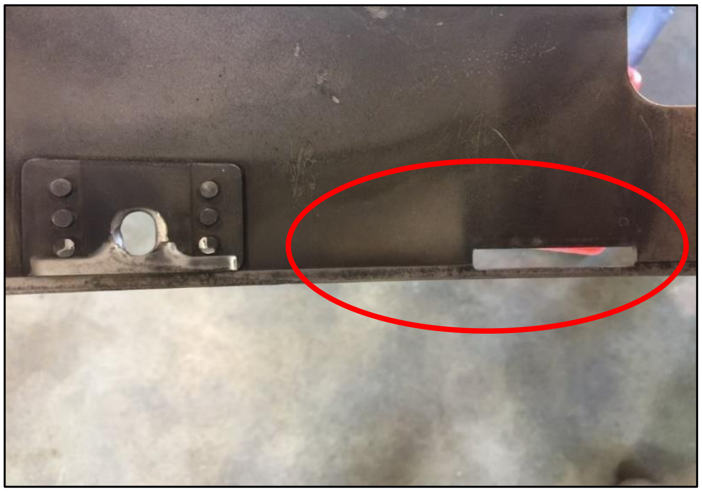


Figure 13: Forward fairing wear bracket worn through fairing (Tab Z-8)

Figure 14 shows the external view and fire damage on the ME. (Tab CC-73) The only visible damage from the mishap is on the back right-hand side of the engine. (Tab CC-73)

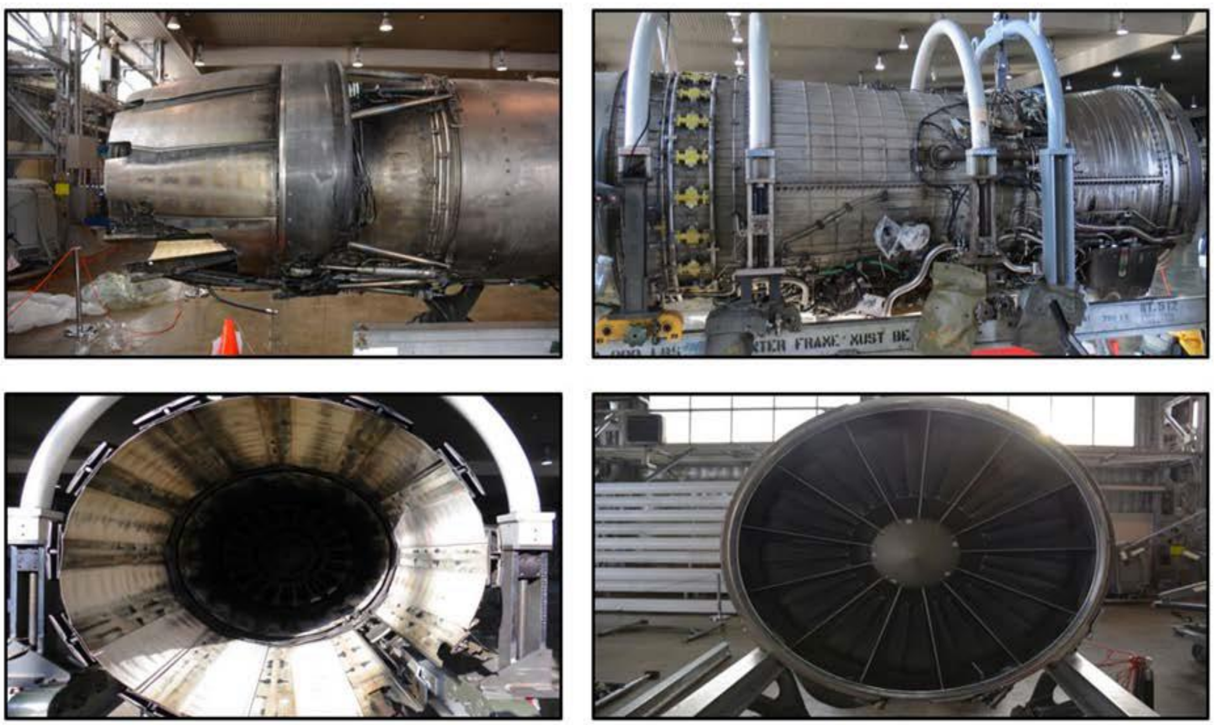


Figure 14: External view of Engine 538133 (Tab CC-65)

The engine's exhaust nozzle suffered extensive fire damage as shown in **Figure 15**. (Tab CC-73) The damage occurred from about the 3:00 to 6:00 position. (Tab CC-73)

Figure 15: Exhaust nozzle burn damage from 3:00 to 6:00 (Tab CC-73)

Figure 16 shows a close-up view inside the exhaust nozzle assembly. (Tab CC-74) The exhaust duct liner and the exhaust duct were burned completely through at the 4:30 position as a result of the fire. (Tab CC-74) In normal engine operation, a film of cooling air exists between the exhaust nozzle duct and the exhaust nozzle liner. (Tab CC-74) This air lowers the metal temperature of the exhaust duct liner during engine operation. (Tab CC-74) Without proper cooling air, the liner cannot withstand the temperatures of the hot engine gases from the exhaust. (Tab CC-74)

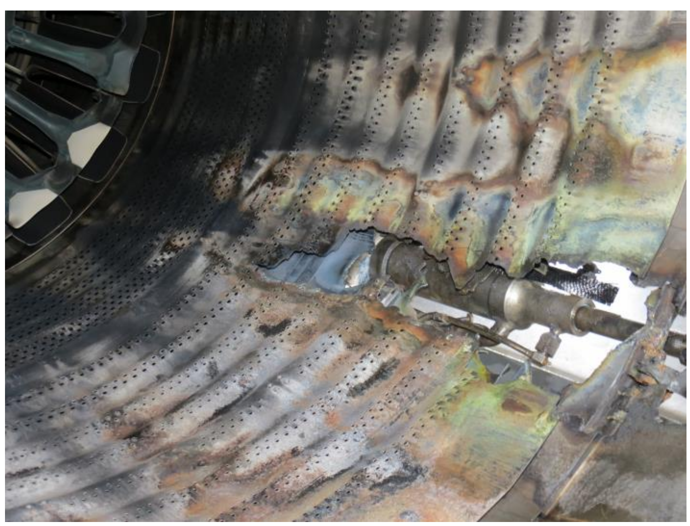


Figure 16: Burn-through on exhaust duct liner and duct at 4:30 (Tab CC-74)

The fire also caused the A8 actuator supply line at the 4:30 position to rupture and leak hydraulic oil. (Tab CC-74) The A8 actuators control the diameter of the nozzle during normal flight operations. (Tab CC-74) Decreasing the diameter of the nozzle allows the engine to produce thrust. (Tab CC-74) With the A8 actuators' hydraulic line ruptured, the MP was unable to decrease the diameter of the nozzle, creating a noticeable decrease in engine thrust. (Tab CC-74)

e. Impact

Not applicable.

f. Egress and Aircrew Flight Equipment (AFE)

The MP ground egressed without incident on the runway. (Tab V-17.8) AFE was not used during ground egress. (Tab V-17.8)

g. Search and Rescue (SAR)

Not applicable.

h. Recovery of Remains

Not Applicable.

5. MAINTENANCE

a. Forms Documentation

Air Force Technical Order (AFTO) Form 781 collectively documents maintenance actions, inspections, servicing, configuration, status, and flight activities for the aircraft. Integrated Maintenance Data System (IMDS) is a comprehensive database used to track maintenance actions, flight activity, and schedule future maintenance. (Tab D-504-566) Comprehensive Engine Management Systems (CEMS) is a comprehensive database used to track engine parts, maintenance, and inspections. (Tab D-504-566)

A review of Air Force Technical Order (AFTO) Form 781 revealed no discrepancies indicating any noticed mechanical or flight control anomalies, or any structural or electrical failure on the MA. (Tab D-1-1688) IMDS historical records were reviewed 10 years prior to the MM and CEMS records were reviewed for the 8 years prior to the MM. (Tab D-504,1107) A review of the historical records also confirmed that no TCTO were overdue at the time of the MS. (Tab D-1-1688)

b. Inspections

The MA had 7,192.1 total flight hours at the time of the mishap. (Tab D-3) The GE F-110129 engine, serial number GE0E538133, installed in the MA had 4,976.6 Flying Hours (FHR) total. (Tab D-3)

Technical Order (TO) 1F-16CJ-6-11 mandates an 800 Engine Flight Hour (EFH) Exhaust Nozzle Inspection which requires a borescope camera be used to get a detailed view of the forward fairing. (Tab CC-70, Tab BB-5-9) This inspection requires the use of a borescope camera that has digital measurement capability. (Tab CC-70) The inspector is required to check the full circumference of the forward fairing to look for cracks, loose/missing hardware, and wear on the forward end of the fairing. (Tab CC-70) In the inspection, maintainers must ensure the fairing has a thickness of at least .040 millimeters; if not, maintainers must replace the fairing. (Tab BB-8) Historical evidence has shown that the wear on the fairing gets worse with time and generally fails at .010 and .020 millimeters. (Tab U-22) The borescope inspection was last performed on the ME and the mishap forward fairings on 06 July 2016, when the mishap forward fairing had been on the ME for 373 flight hours. (Tab U-22) The historical data indicates the forward fairings were cracking after the fairings had endured approximately 700 to 900 hours, so it is unsurprising that the 06 July 2016 borescope inspection did not indicate a potential problem with the mishap forward fairings. (Tab U-22)

In addition to the 800 EFH inspection, TO 1F-16CJ-6-11 requires a naked eye inspection of the aircraft and its forward fairing, each time an aircraft takes off and lands. (Tab BB-15, Tab CC-78) The Preflight (PR) inspection is conducted before takeoff and the Basic Post flight (BPO) is conducted when the aircraft lands. (Tab D-86) Among other potential issues, these inspections are designed to find major damage to the fairing, such as liberated pieces that have lifted into the air stream. (Tab CC-78) Maintenance personnel accomplish these inspections by crawling inside of the exhaust nozzle and using a bright light to look at the forward fairing, among other areas. (Tab CC-78) Given the inward position of the forward fairing, it is highly unlikely that this inspection would reveal minuscule wear on the fairing, as the viewer is unable to get physically closer than 18 to 24 inches from the fairing. (Tab U-22) The most recent of these inspections on the MA were PR/BPO completed at 1335L on 16 February 2018, PR completed at 1600L on 17 February 2018, and a WAI completed at 0100L on 20 February 2018. (Tab D-86)

The reviewed maintenance documentation confirmed that maintenance personnel accomplished all required scheduled inspections in accordance with applicable directives and that improper inspections did not contribute to the mishap. (Tab D-3-177)

c. Maintenance Procedures

Maintenance procedures are described in applicable Technical Orders (TO), Air Force Instructions (AFI), and local procedures.

Maintenance procedures were properly followed on the ME when complying with TCTO-682 on 3 June 2010, indicating that the updated fairing and hardware were installed correctly at that time. (Tab CC-72) This is indicated by the fact that the parts required to complete TCTO-682 were issued as a complete kit and that the correct attaching hardware for that TCTO was found to be installed on the date of the mishap. (Tab CC-72) However, inspection of the ME after the mishap revealed that all three segments of the fairing were the obsolete versions.

The only events that would drive removal or replacement of the forward fairing is if the fairing was damaged (discovered during inspection), if a turbine frame assembly required removal, or if a low pressure turbine (LPT) assembly required removal. (Tab CC-72) The following timeline details the only recorded events after 3 June 2010 when the forward fairing would have been removed or exposed for close visual inspection: (Tab CC-72)

1. 23 November 2010 - 07 January 2011: LPT Rotor Assembly Removed/Reinstalled

2. 03 March 2012: ME removed from A/C 91-0411 for turbine nozzle damage and TCTO 2J-F110129-659 mandates a Structural Life Extension Program (SLEP). On 12 March 2012, the LPT Rotor Assembly was removed from the engine. The pre-TCTO forward fairings were ordered on 16 March 2012. On 24 September 2012, the LPT Rotor Assembly was reinstalled, and on 02 October 2012, the SLEP was completed.
3. 12 -13 February 2013: Augmenter/Exhaust Assembly Removed/Reinstalled.

While the augmenter/exhaust assembly was replaced on 12 February 2013, there is no mention in CEMS that the fairing was removed during that action. Therefore, the last recorded maintenance activity where the forward fairing and its respective brackets and hardware were installed would have been on 24 September 2012 during installation of the LPT Rotor Assembly during the SLEP upgrade of the engine. A SLEP is a major engine overhaul that includes the complete teardown of the engine.

During the SLEP, on 16 March 2012, the 35 MXS Propulsion Flight ordered three obsolete segments that comprise the forward fairing. (Tab U-23-25) The signatures on the issuing forms for these three segments, which would have shown who specifically received the obsolete parts, are illegible. (Tab U-23-25) The Propulsion Flight's Jet Engine Intermediate Maintenance (JEIM) section then installed three obsolete segments comprising the forward fairing onto the ME using the updated brackets and hardware. (Tab U-27) In accordance with standard procedures, this installation and the corresponding records were reviewed by at least one supervising technician that failed to catch the error. (Tab U- 27)

During the 2012-2015 timeframe, the JEIM section had poor enforcement of standard maintenance protocols. (Tab CC-19, Tab CC-23) This created an environment that tolerated: improper completion of paperwork to ensure parts accountability, severe disorganization at the shop, and the improper handling of parts, including a failure to separate serviceable and unserviceable parts, and failure to follow proper procedures for cannibalization (CANN) actions. (Tab CC-19, Tab CC-23)

Witness testimony indicates that the work section was significantly disorganized during that period. (Tab V-8.1) The shop possessed substandard accountability and tracking of engine parts during extensive engine teardowns and rebuilds. (Tab V-8.1) A Report of Survey (ROS) provides insight into the flight's environment in 2012. (Tab CC-19) Witness testimony and maintenance documentation from ROS #15-033 indicates the Propulsion Flight failed to properly document maintenance actions, with one example showing they entered information into a tracking system to indicate a particular Airman removed a part, while also entering information into a separate tracking system indicating that a different Airman removed the same part. (Tab CC-19-35) This ROS also indicates that a part worth $3K was likely misidentified and turned in for scrap. (Tab CC-19) A second ROS detailing practices from 2013 to 2015 further supports that this Propulsion Flight had a history during 2012 of poor paperwork and accountability as it discussed a search for $322K worth of parts, most of which eventually turned up on aircraft across the world without any documentation to show how it left the Propulsion Flight. (Tab CC-23) This ROS also discussed parts that had likely been misidentified and turned in as scrap, or sent to headquarters for repair or redistribution. (Tab CC-23)

In 2015, the propulsion shop was in disarray, as there were no parts shelves, excess parts and boxes were left in the work area, there were old bins of material, and there was "stuff everywhere" without much organization. (Tab V-10.1) This deviates from standard protocols since building a motor takes "details, parts, and room." (Tab V-8.1) It was "mix and match," with no standardization of where things went. (Tab V-8.1) There was no designated area to put a turbine frame. (Tab V-8.1) The shop had their own "method of the madness". (Tab V-8.1) Given these departures from standard protocols, the propulsion shop received a half million dollars to revamp the shop, in order to get the shop back up to standards. (Tab V-16.1)

According to the 35 MXS Commander from 2013-2015, the shop was known to have disorganized accountability practices where serviceable and non-serviceable parts were stored in the same area. (Tab V-16.1) Additionally, protocols regarding cannibalization (CANN), when maintenance personnel could take a serviceable part off one piece of equipment to use on another, were not enforced. (Tab CC-20) This led to CANN procedures in 2012 that were not precise or were happening below the authorized authority level. (Tab CC-20) The documentation for these actions was also not completed properly. (Tab CC-20) Certain flights had little or no supervision involved in their processes. A part that should have been carefully tracked, was likely misidentified and turned in as scrap metal. (Tab CC-29) A similar report, for different parts, found that several parts were removed and installed on other engines without proper documentation or authorization. (Tab CC-29)

35 MXS Propulsion Flight procedures have since been corrected and continuously improved upon by supervision and personnel. (Tab CC-19-35) Supervision and personnel are currently operating within guidelines set forth by the AFIs, TOs, and local procedures. (Tabs O-1-4.2)

d. Maintenance Personnel and Supervision

AFI 36-2650, *Maintenance Training*, 20 May 2014, Chapter 3, provides the requirements for documenting maintenance training, and a review of the records of personnel who serviced or maintained the systems of the MA indicated proper training and full qualifications on all tasks accomplished. (Tab BB-61 to BB-62) As such, there is no evidence to suggest that personnel qualifications were a factor in the mishap.

However, inadequate supervision was a factor in the mishap. While personnel and training records did not reveal inadequate supervision, witness testimony and other documentation of the Propulsion Flight's environment from 2012-2015 did indicate poor enforcement of standard maintenance protocols that was a substantially contributing factor to the order and installation of the obsolete forward fairing. (Tab V-8.1-8.2)

e. Fuel, Hydraulic, Oil, and Oxygen Inspection Analysis

Laboratory tests determined that Jet Propellant-8 (JP-8) aviation turbine fuel, hydraulic fluid, and aircraft engine oil samples taken post-accident from servicing equipment were within limits and free of contamination. (Tab U-20-21)

f. Unscheduled Maintenance

A review of the MA's performance for the 90-day period prior to the MS, revealed 48 of 53 sorties flown landed either Code I (fully mission capable) or Code II (with minor discrepancies, partially mission capable) and zero repeats or recurs. (Tab U-2) According to AFI 21-101, *Aircraft and Equipment Maintenance Management*, 21 May 2015, a repeat discrepancy is defined as a discrepancy that occurs on the next sortie or attempted sortie after corrective action has been taken and the system or sub-system indicates the same malfunction when operated. (Tab O-4.2) A recurring discrepancy is one that occurs on the second through fourth sortie or attempted sortie after corrective action is taken and the system or sub-system indicates the same malfunction when operated. (Tab O-4.2)

The MA flew 53 sorties in the 90 days prior to the MS and received five Code III discrepancies that rendered the aircraft non-mission capable. (Tab U-2) These discrepancies did not involve any systems pertaining to the MS, and are not significant to this investigation. (Tab U-2)

g. Time Compliance Technical Orders (TCTO)

TCTOs are the authorized method of directing and providing instructions for modifying military systems and end items or performing one-time inspections. (Tab BB-2) Historical records showed that all required TCTOs had been accomplished on the ME in accordance with applicable guidelines. (Tab D1-1688)

The primary TCTO at issue here, TCTO-682, was driven by the fact that during the early to mid-2000 timeframe, both the U.S. Air Force and foreign military operators of the F110129 engine began experiencing excessive wear, cracking and, in a few cases, failure of the turbine frame forward fairing. (Tab CC-69) Most of these fairings were found to be wearing on the front end where they would become thin, crack, and sometimes fail. (Tab CC-77) **Figures 18 and 19** show a previous fairing failure that occurred in 2009. (Tab CC-77) Note the similarities between **Figure 16** from this mishap and the 2009 fairing failure. (Tab CC-77)

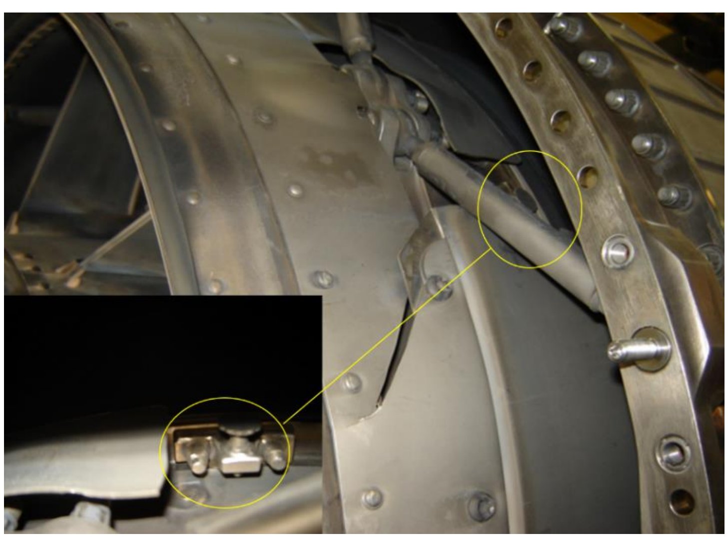


Figure 17: Fairing failure in 2009 event (Tab CC-77)

Figure 18: Exhaust duct liner and duct heat distress from event in 2009 (Tab CC-77)

6. LOGISTICS

On 16 March 2012, 35 MXS Propulsion Flight ordered three obsolete forward fairing segments. (Tab U-24) The three segments that were obsolete as of 17 August 2010, are displayed in **Figure 19** along with the part numbers they replaced. (Tab J-14)

Pre-TCTO 682 Fairing Part Number	TCTO 682 Fairing Part Numbers
1784M21G03	**2131M74G01**
1784M22G02	**2131M75G01**
1784M23G02	**2131M76G01**

Figure 19: Turbine Frame Part Number Comparison (Tab J-14)

One fairing segment, part number 1784M21G03, was ordered and issued in March 2012. (Tab U-24) Two fairing segments, part number 1784M23G02, were also ordered. (Tab U-25) However, the corresponding issuing form for these two segments, the DD Form 1348-1A, indicated a "replaced by" National Stock Number (NSN) in the nomenclature section of the form with the NSN for part number 2131M76G01. (Tab U-25) This indicates that, despite the order for two obsolete segments, two updated segments should have actually been issued. (Tab U-25) There is no evidence to verify that the updated segments were actually issued.

The three obsolete segments that were ordered in March 2012 should not have even been available for issue to the 35 MXS since they were obsolete as of August 2010. (Tab V-11.1) If the obsolete segments had been properly removed from the supply chain, the parts would have been flagged as "not loaded" and the order could not have been placed or would have been automatically replaced with the updated part number. (Tab V-11.1) Thus, the logistical system allowed at least one obsolete segment to be ordered. (Tab U-24)

A review of the supply system programs, Enterprise Solutions System (ESS) and Logistics Installation and Mission Support – Enterprise View (LIMS-EV), verified that none of the three obsolete fairing segment part numbers are currently available for issue. (Tab U-26-29)

7. AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS

a. Flight Controls

The flight controls operated normally during the mishap. (Tab V-17.19)

b. Avionics/Communications

Maintenance fault lists (MFLs) and pilot fault lists (PFLs) are indications of aircraft discrepancies displayed in the cockpit. (Tabs U-17-19) The MA had no grounding MFLs or PFLs prior to the MS. (Tab D-168-177) The MA had the following PFLs during the MS: 18 (Augmenter Inhibit), 19 (Hybrid Mode), and 43 (A8 Hydraulic Pump). (Tab D-168-177) All three PFLs were directly related to the augmenter burn through.

c. Hydraulic System

The hydraulic system operated normally during the mishap. (Tab V-17.19)

d. Fuel System

The fuel system operated normally during the mishap. (Tab V-17.19, Tab U-21)

e. Electrical System

The electrical system operated normally during the mishap. (Tab V-17.19)

f. Life Support and Egress

The life support and egress systems operated normally during the mishap. (Tab V-17.19)

g. Oil System

The engine was operating upon landing and the Joint Oil Analysis Program (JOAP) sample came back within the acceptable range to indicate no problems with the engine bearings. (Tab U-20) The oil was drained and it was determined that an adequate amount was present even with oil loss during the MS. (Tabs J-19, U-20)

h. Engine

The Mishap Engine (ME) E538133 received TCTO-682 (Turbine Frame Outer Fairings Upgrade) on 03 June 2010 at Spangdahlem AB, Germany, with 3550.6 hours of inflight time (IFT) recorded from the engine. (Tab D-522) A major engine overhaul event, known as Service Life Extension Program (SLEP), was conducted at Misawa AB, Japan from 03 March 2012 to 02 October 2012, with 3788.3 IFT. (Tab D-1170) It was during this overhaul that the ME was completely disassembled, inspected, had parts replaced or reinstalled, and was tested while it was uninstalled on an aircraft at a test facility. (Tab V-9.2 to V-9.4)

i. Landing Gear

The landing gear operated normally during the mishap. (Tab U-2-16)

8. WEATHER

a. Forecast Weather

The weather forecast for the MS predicted few clouds at 2,000 feet and scattered clouds at 3,000 feet. (Tab F-2) The term "few" refers to cloud layers that cover up to 25% of the sky and the term "scattered" refers to cloud layers that cover less than 50% of the sky. (Tab BB-27) The visibility was forecast to be seven statute miles. (Tab F-2) The wind was forecast to be 270 degrees at eight knots. (Tab F-2)

The weather in the mission airspace was forecast to have a scattered to broken cloud layer from 3,000 to 8,000 feet. (Tab F-2) The term "broken" refers to cloud layers that cover more than 50% of the sky. (Tab BB-27)

b. Observed Weather

The weather at Misawa AB at 0900L, twenty-one minutes after the mishap, was reported as unlimited visibility with winds from 260 degrees at twelve knots. (Tab F-5)

c. Space Environment

Not applicable.

d. Operations

The MS was conducted in accordance with all applicable operational weather regulations. (Tab F-2, F-5)

e. Conclusion

There is no evidence to suggest weather was a factor in the mishap.

9. CREW QUALIFICATIONS

a. Training

The MP was current and qualified for the mission on 20 February 2018. (Tab G-21) The MP completed his initial F-16 instrument check ride on 29 September 2015. (Tab G-27) Upon arriving at Misawa AB, the MP completed his initial mission check ride on 08 January 2018 and was certified as a combat mission ready wingman. (Tab G-27). The MP's last emergency procedures simulator prior to the accident was on 12 February 2018. (Tab G-13)

b. Experience

The MP is an inexperienced AF pilot. (Tab G-21) At the time of the mishap, the MP had accumulated 529.2 total flight hours, 301.5 hours of which were in the F-16C/D. (Tab G-25,26)

The MP flew two sorties in the two weeks prior to the mishap. (Tab G-20) A breakdown of the MP's 30/60/90 day flight history is as follows: (Tab G-18, 19)

	Hours	Sorties
Last 30 Days	7.1	5
Last 60 Days	16.8	11
Last 90 Days	32.5	19

There is no evidence to suggest the MP's training or experience were a factor in the mishap.

10. MEDICAL

a. Qualifications

At the time of the mishap, the MP was medically qualified for flight duty without physical restrictions or waivers. (Tab X) The MP's most recent annual flight physical, on 21 March 2017, determined he was medically qualified for flight and worldwide military duty

Additionally, all members of the formation and maintenance crew members recently involved with the MA were also medically qualified for duty. (Tab X) There is no evidence to suggest medical qualifications were a factor in the mishap.

b. Health

Medical and dental records revealed the MP was in good health and had no recent performance-limiting illnesses prior to the mishap. (Tab X) After interviewing the MP and thoroughly reviewing his records, there was no evidence that any medical condition contributed to the mishap. (Tab V-1, Tab X)

A qualified flight surgeon conducted a post-accident physical exam on the MP and noted no injuries. (Tab X) The MP made no significant medical complaints related to the mishap.

c. Pathology

Immediately following the mishap, toxicology testing was conducted on the MP and maintenance crew members who were recently involved with the MA. (Tab X) Blood and urine samples were submitted to the Armed Forces Medical Examiner System (AFMES) for toxicological analysis (carbon monoxide, ethanol levels, and drugs). (Tab X) Results for the MP and maintenance crew members were normal. (Tab X)

d. Lifestyle

Witness testimony as well as a review of the MP's seven days leading up to the incident revealed no unusual habits, behavior, or stress. (Tab X) There is no evidence to suggest lifestyle factors were a factor in the mishap.

e. Crew Rest and Crew Duty Time

AFI 11-202, Volume 3, General Flight Rules, requires aircrew members to have a minimum 12-hour non-duty period before the designated flight duty period begins. (Tab BB-23) Crew rest is free time and includes time for meals, transportation, and rest. (Tab BB-23) This time must include an opportunity for at least 8 hours of uninterrupted sleep. (Tab BB-23) The MP complied with crew rest and duty day requirements prior to the mishap. (Tab R-41, R-42, R-43) There is no evidence to suggest crew rest was a factor in the mishap.

11. OPERATIONS AND SUPERVISION

a. Operations

On the day of the mishap, the squadron had 37 assigned pilots. (Tab G-21, 22) Of those 37 pilots, 27 were experienced and 10 were inexperienced. (Tab G-21, 22) Overall, the operations tempo at Misawa AB is relatively high compared to the rest of Combat Air Force (CAF), but typical for the Misawa AB F-16 squadrons. (CC-18) Operations tempo was determined not to be a factor in the mishap.

b. Supervision

The MM was led by the MLP, an experienced instructor pilot (IP). (Tab AA-2, T-8) The SOF was qualified in that duty position. (Tab G) There is no evidence to suggest pilot supervision was a factor in the mishap.

12. HUMAN FACTORS ANALYSIS

a. Introduction

The board evaluated human factors relevant to the mishap using the analysis and classification system model established by the Department of Defense (DoD) Human Factors Analysis and Classification System (HFACS) guide, Version 7.0, implemented by Air Force Instruction AFI 91-204, *USAF Safety Investigations and Reports*, dated 19 January 2018. (Tab BB-39) Human factors describe how our interaction with tools, tasks, working environments, and other people influence human performance. (Tab BB-39) The DoD created a model to engage in a systematic, multidimensional approach to error analysis and mishap prevention. (Tab BB-39)

The framework is divided into four main categories: Organizational Influences, Supervision, Preconditions, and Acts. (Tab BB-39) Each category is further divided into related human factor categories which are further divided into subcategories. (Tab BB-60) The main categories allow for a complete analysis of all levels of human error and how they may interact together to contribute to a mishap. (Tab BB-39) This framework allows for evaluation of any unsafe acts that are directly related to the mishap by considering the indirect preconditions, supervision, or organizational influences that may have led to the mishap. (Tab BB-39) The relevant factors to this mishap are discussed below**.**

b. Human Factors

<u>Organizational Influences</u> Organizational influences are defined as factors in a mishap if the communications, actions, omissions, or policies of upper-level management directly or indirectly affect supervisory practices, conditions, or actions of the operator(s) and result in system failure, human error, or an unsafe situation. (Tab BB-45) Following review of all testimonies and mishap data, the AIB found some organizational influences that were contributory to the mishap. (Tab BB-42)

Resource Problems (OR000): are factors when processes or polices influence the safety system, resulting in inadequate error management or creating an unsafe situation. (Tab BB-42) Following review of all testimonies and mishap data, the AIB found some resource problems that were significant to the mishap. Below is a discussion and analysis of resource problems that the board felt were significant to the mishap.

Failure to Remove Inadequate/Worn-Out Equipment in a Timely Manner (OR005): is a factor when the process through which equipment is removed from service is inadequate. (Tab BB-42) As discussed in Section 5 of this report, the Air Force released TCTO-682 mandating that all forward fairings on the F110129 engine be replaced with updated forward fairings, after it determined that the forward fairing was showing excessive wear and cracking. (Tab BB-2) The TCTO directed that the replacements must occur by 07 August 2010, and that the removed fairings be disposed. (Tab BB-2) However, when the ME underwent a SLEP upgrade in 2012, Propulsion Flight personnel were still able to order at least one segment of the obsolete forward fairing through the supply system, even though the Air Force had officially rescinded that part almost two years prior. (Tab U-23-25) Ultimately, the re-installation of the obsolete forward fairing and the wear caused by the updated hardware, was the direct cause of the mishap.

<u>Supervision:</u> Supervision is defined as a factor in the mishap if the methods, decisions, or policies of the supervisory chain of command directly affect practices, conditions, or actions of the individual and result in human error or an unsafe situation. (Tab BB-39)

Supervisory Violations (SV000): are factors when supervisors willfully disregard instructions or policies. (Tab BB-39) Following a review of witness testimonies and mishap data, the AIB determined that failed supervisory influences substantially contributed to the mishap. (Tab BB-39) Below is a discussion and analysis of supervisory violations significant to the mishap.

Failure to Enforce Existing Rules –Supervisor Act of Omission (SV001): is a factor when unit (organizational) and operating rules have not been enforced by a supervisor. (Tab BB-7)

Maintenance supervision failed to enforce several operating rules during the timeframe associated with the order and installation of the obsolete forward fairing. (Tab CC-19) The first rule supervision failed to enforce was the proper completion of paperwork to ensure parts accountability, resulting in $322K in unaccounted parts. Second, supervision failed to enforce and ensure a physically-organized work environment. (Tab CC-25) Third, supervision failed to enforce proper parts handling, to include maintaining serviceable and unserviceable parts separate, and ensuring those allowing cannibalization (CANN) actions have the proper authority to do so and are properly documenting those actions. (Tab CC-25) This failure to enforce operating rules created an environment of unenforced rules and protocols, in a squadron that must be fastidious when following technical orders, as a failure to do so can result in the ordering of an obsolete part. (Tab CC-18) Supervision's failure to enforce existing rules was a contributing factor to the mishap. (Tab CC-19)

<u>Preconditions (Environment):</u> The environment surrounding a mishap is the physical or technological factors that affect practices, conditions, and actions of individual(s) and result in human error or an unsafe condition. (Tab BB-32) Following a review of witness testimonies and mishap data, the AIB determined environment was significant to the mishap. (Tab BB-32)

Technological Environment (PE200): are factors when automation or the design of the workspace affect the actions of an individual(s). (Tab CC-30) A review of witness testimonies and mishap data revealed some haphazard environmental preconditions that were contributory to the mishap. (Tab BB-33) Below is a discussion and analysis of environmental preconditions that the board felt were significant to the mishap.

Workspace Incompatible with Operation (PE206): is a factor when the workspace is incompatible with the task requirements and safety for an individual. (Tab BB-33) During the 2012 timeframe when the obsolete forward fairing was ordered and installed, the Propulsion Flight was severely disorganized. (Tab V-10.1) There were no part shelves, there were excess parts and boxes in the work area, old bins, and "stuff everywhere." (Tab V-8.2) While the shop had its "method of the madness," there was not a lot of organization. (Tab V-8.2) An engine takes "details, parts, and room." (Tab V-8.2) The Propulsion Flight did not have that. (Tab V-8.2) Additionally, each engine dock station was mixed and matched, with no standardization between dock stations for where items should go. (Tab V-8.2) This haphazard maintenance environment contributed to the mishap.

<u>Acts:</u> The environment surrounding a mishap is the physical or technological factors that affect practices, conditions, and actions of individual(s) and result in human error or an unsafe condition. (Tab BB-7) Following a review of witness testimonies and mishap data, the AIB determined failure to follow procedures were casual to the mishap. (Tab BB-7)

Procedure Not Followed Correctly (AE103): is a factor when a procedure is performed incorrectly or accomplished in the wrong sequence. (Tab BB-7) When Propulsion Flight personnel ordered and installed the obsolete forward fairing in 2012, the current TO clearly indicated, right next to the part number for the forward fairing, that a TCTO had rescinded the previous part number. (Tab BB-18) The updated part number for the updated forward fairing was listed along with the rescission information. (Tab BB-18) If the maintenance personnel had properly referenced the TO or used the part number from the part the maintenance personnel was removing, the correct part would have been ordered. (Tab V-10.2) There are two alternatives to explain how the obsolete fairing was ordered: 1) maintenance personnel referenced the TO and they unreasonably did not see the note indicating the part had been replaced, or 2) maintenance personnel used a unit-created Quick Reference List (QRL) to look up the part number and the QRL had not been updated since 2010 to reflect the new part number. (Tab V-10.2) Either of these alternatives indicate that maintenance personnel were not following proper procedures when ordering the replacement forward fairing during the 2012 SLEP upgrade. This failure to follow procedures contributed to the mishap.

13. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Publically Available Directives and Publications Relevant to the Mishap

(1) AFI 21-101, Aircraft and Equipment Maintenance Management, 21 May 2015
(2) AFH 11-203, Vol 1, Weather for Aircrews, 12 January 2012
(3) AFI 11-202, Vol 3, General Flight Rules, 10 August 2016
(4) AFI 48-123, Medical Examinations and Standards, 19 September 2016
(5) AFI 11-2F-16v3, F-16 Operations Procedures, 13 July 2016
(6) AFI 91-204, Safety Investigations and Reports, 12 February 2014
(7) AFI 36-2650, Maintenance Training, 20 May 2014

NOTICE: All directives and publications listed above are available digitally on the Air Force Departmental Publishing Office website at: http://www.e-publishing.af.mil.

b. Other Directives and Publications Relevant to the Mishap

(1) TO 00-20-1, Aerospace Equipment Maintenance Inspection, Documentation, Policies, and Procedures, 11 July 2016
(2) TO 00-20-2, Maintenance Data Documentation, 15 March 2016
(3) Medical Standards Directory, 29 November 2016
(4) DoD Human Factors Analysis and Classification System, Version 7.0
(5) AFI 21-101, Aircraft and Equipment Maintenance Management, 26 July 2010
(6) AFI 36-2232, Maintenance Training, 22 February 2006

c. Known or Suspected Deviations from Directives or Publications

TCTO-682 required that all obsolete forward fairings be replaced with fairings made of a stronger composite material and updated design which included wear strips. TCTO-682 required all titanium forward fairings be replaced by 07 August 2010. Although the ME had its obsolete fairings properly replaced in 2010, the updated fairings were later erroneously re-replaced with the obsolete fairings during an engine Service Life Extension Program (SLEP) in 2012. The obsolete fairing had been on the ME for approximately 760 flight hours when it failed.

14. ADDITIONAL AREAS OF CONCERN

a. Jettisoned F-16 Fuel Tank Response/Recovery Operations

The 35 FW conducted recovery operations beginning on 20 February 2018 and concluding on 16 March 2018. (Tab CC-37) The two jettisoned fuel tanks landed off-base in Lake Ogawara, coordinates: 40.73241N, 141.31279E. (Tab CC-37) On the day of the accident, the 35 FW Commander directed the 35th Civil Engineer Squadron, to include the Environmental Section (CES/CEIE), to respond to the scene. (Tab CC-37) The Wing's Emergency Operations Center (EOC) stood-up and an initial Unites States Forces Japan (USFJ) Form 50 spill report was processed to USFJ through the Misawa AB Command Post detailing the accident.

The dropped fuel tanks had a max capacity each of 370 gallons of JP-8. (Tab CC-37) The tanks contained approximately 300 gallons each at the time they were jettisoned. (Tab U-4) The Crash Survivable Flight Data Recorder (CSFDR) indicated the total weight of two tanks with JP-8 was 896 pounds. (Tab U-4)

The fuel tank response, recovery, and clean-up process was supported by: 35 FW, Air Force Civil Engineer Center (AFCEC), Japanese Maritime Self Defense Forces (JMSDF), Japanese Ministry of Defense (MOD), The Tohoku Defense Bureau (TDB), Japanese Government Ministry of Land, Infrastructure, Transport and Tourism (MLITT), United States Navy Pacific Fleet Salvage Unit, and Japanese Master Labor Contractors (MLCs). (Tab CC-41) Further, local fishermen were instrumental in the recovery effort, notably, as they provided fishing vessels used in salvage and clean-up operations.

JMSDF and US Navy dive teams began recovery operations on 24 February 2018 and concluded on 13 March 2018. (Tab CC-42) There was an initial delay in getting boats to the site as there was difficulty locating boats in the local area that were capable of handling the large heavy equipment necessary to conduct recovery and clean-up operations. (Tab Z-16-18)

Figure 20 shows portions of the fuel tanks recovered during salvage operations. Overall, 99.9% of the fuel tank material was collected from Lake Ogawara, totaling 895.75 pounds. (Tab U-4) All response and recovery operations concluded on 16 March 2018.

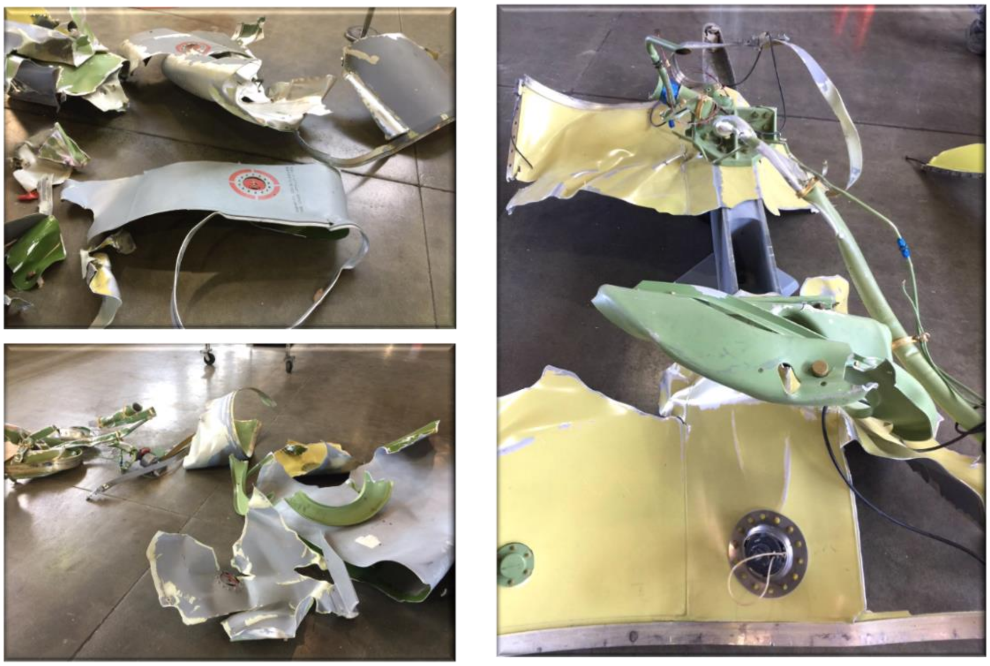


Figure 20: F-16CM External Fuel Tanks-recovered material from Lake Ogawara

The 35 FW Spill team operations began on 28 February 2018 and the 35th Logistics Readiness Squadron (35 LRS) provided a Material Safety Data Sheet (MSDS) for the most recent shipment of JP-8 to the Wing, which outlined the additives contained in the fuel. (Tab CC-37) This data was used during the response process when numerous water samples were taken throughout the period from 22 February 2018 through 09 March 2018. (Tab CC-36)

On 15 March 2018, 35 FW personnel, the TDB, and the Japanese MLITT met to review and compare water sample test taken during the response process. (Tab CC-43) MLITT tested for mineral oil, benzene, total petroleum, hydrocarbons (TPH), all of which were negative on 10 March 2018. (Tab CC-43) The 35 FW water tested for Suspended Solids (SS), Potential of Hydrogen (PH), Chemical Oxygen Demand (COD), and Dissolved Oxygen (DO) and all were reported to be within normal ranges for Lake Ogawara on 15 March 2018. (Tab CC-75) On 20 March 2018 the local Japanese government declared Lake Ogawara open. (Tab CC-44)

24 July 2018

SERGIO J. VEGA, Colonel, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

F-16CM, T/N 92-3883
MISAWA AIR BASE, JAPAN
20 February 2018

Under 10 U.S.C. § 2254(d) the opinion of the accident investigator 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

I find by a preponderance of the evidence that the mishap aircraft (MA) experienced an engine fire shortly after take-off from runway (RWY) 28 at Misawa Air Base (AB), Japan because an obsolete turbine frame forward fairing on the mishap engine (ME) failed during takeoff. Evidence collected from the Crash Survivable Flight Data Recorder (CSFDR) and the ME, to include the augmenter/exhaust nozzle assembly, indicate the turbine frame forward fairings failed. During the mishap pilot's (MPs) takeoff, the installed turbine forward fairing segment fractured, causing portions of the fairing to lift into the cooling airflow between the exhaust liner and the flame produced by the afterburner. Without the cooling air, the exhaust liner and the downstream components were exposed to temperatures beyond their heat tolerance, resulting in a fire.

The obsolete forward fairings had previously been called to be replaced by Time Compliance Technical Order 2J-F110129-682 (TCTO-682) in 2007. TCTO-682 required that all obsolete forward fairings be replaced with fairings made of a stronger composite material and updated design which included wear strips. TCTO-682 required all titanium forward fairings be replaced by 07 August 2010. Although the ME had its obsolete fairings properly replaced in 2010, the updated fairings were later erroneously re-replaced with the obsolete fairings during an engine Service Life Extension Program (SLEP) in 2012. The obsolete fairing had been on the ME for approximately 760 flight hours when it failed.

The Heads Up display (HUD) video, Crash Survivable Flight Data Recorder (CSFDR), tower transcripts, and a review of the Supervisor of Flight (SOF), mishap lead pilot (MLP), and MP's testimony, confirms the MP flew and landed the MA in accordance with flight manual and critical action procedures. The MP emergency jettisoned his fuel stores in accordance with the F-16CM fire-in-flight critical actions procedures. The MP's actions during the mishap flight were focused, precise, and appropriate; his actions did not contribute to the mishap.

The MA sustained engine damage and loss of external stores, which contained fuel. While not the cause, I find by a preponderance of the evidence that the haphazard practices by the maintenance Propulsion Flight during 2012 were a substantially contributing factor to the mishap.

I developed my opinion by analyzing factual data from historical records, guidance and directives, engineering analysis, witness testimony, and information provided by technical experts.

2. CAUSE

The cause of the 20 February 2018 engine fire was due to the installation of obsolete forward fairings which were susceptible to failure. TCTO-682 was released in 2007 requiring titanium forward fairings that had been failing to be replaced with stronger redesigned forward fairings. TCTO-682 required replacement of all titanium forward fairings with enhanced forward fairings by 07 August 2010. It also required the installation of improved brackets as well. Both required maintenance items were completed on the ME on 03 June 2010. I believe the TCTO was actually completed in June 2010 because of proper documentation in the maintenance paperwork, the fact that the updated parts were issued as a complete kit, and that the correct attaching hardware for that TCTO was installed on the date of the mishap.

During a SLEP upgrade of the ME at Misawa AB, Japan, between March and October 2012, 35th Maintenance Squadron (35 MXS), Propulsion Flight, Jet Engine Intermediate Maintenance (JEIM) personnel, erroneously ordered the obsolete titanium forward fairing, instead of the updated enhanced forward fairing. The logistics supply system allowed at least one segment of the obsolete forward fairing to be ordered and delivered, despite the obsolete status of the part. A DD Form 1348-1A Issue and Release document shows the Propulsion Flight ordered the obsolete segments on 16 March 2012. The names of the maintainers that received the parts are illegible.

Once received, JEIM personnel installed the obsolete titanium fairing with the improved brackets. Over time, the post-TCTO brackets exacerbated wear into the fairing, causing it to fracture during the MA's afterburner takeoff on 20 February 2018. During takeoff, the failed forward fairing remained attached on one end, which caused the fractured portion to lift into the cooling airstream of the engine, disrupting essential cooling air to the exhaust nozzle liner and other downstream components. The exhaust liner, in turn, failed, allowing the afterburner flame to burn through the exhaust duct to the outside of the engine. The resulting fire was observable from the ground and caused extensive damage to the downstream exterior engine components. Since the obsolete titanium fairings were new at the time of installation, they would have accumulated 760 flying hours on the day of the mishap.

The only events that would drive removal of the turbine frame forward fairings would be if the fairing was damaged (discovered during inspection), if a turbine frame assembly required removal, or if a low pressure turbine (LPT) assembly required removal. The following details the only recorded events after TCTO-682 was completed when the forward fairing would have been either exposed or been removed/reinstalled: (Tab CC-72)

1. 23 November 2010 - 07 January 2011: LPT Rotor Assembly Removed/Reinstalled
2. 03 March 2012: ME removed from A/C 91-0411 for turbine nozzle damage and TCTO 2J-F110129-659 mandates a Structural Life Extension Program (SLEP). On 12 March 2012, the LPT Rotor Assembly was removed from the engine. The pre-TCTO forward fairings were ordered on 16 March 2012. On 24 September 2012, the LPT Rotor Assembly was

reinstalled, and on 02 October 2012, the SLEP was completed.

3. 12 -13 February 2013: Augmenter/Exhaust Assembly Removed/Reinstalled.

While the augmenter/exhaust assembly was replaced on 12 February 2013, there is no mention in the Comprehensive Engine Management System (CEMS) that the fairing was removed during that action. Therefore, the last recorded maintenance activity where the forward fairing and its respective brackets and hardware were installed, would have been on 24 September 2012 during installation of the LPT Rotor Assembly during the SLEP upgrade of the engine. The obsolete forward fairing has been on the ME since this time, and has not been removed since.

After an in-depth review of the inspection process, I find that the routine inspections conducted on the engine would not have revealed that the incorrect forward fairing was installed or that excessive wear was occurring. The only inspection that was required to be conducted that could have caught the excessive wear was the 800-hour borescope inspection. However, the last 800 hour borescope inspection occurred when the forward fairing had only endured 376 flight hours, a point at which the forward fairing was unlikely to show signs of excessive wear.

3. SUBSTANTIALLY CONTRIBUTING FACTOR: MAINTENANCE PRACTICES

A preponderance of the evidence shows that during the 2012 timeframe, when the obsolete fairing was installed, there was poor enforcement of standard maintenance protocols, which was a substantially contributing factor to the mishap. Poor enforcement of standard protocols led to a failure to follow protocols when ordering and installing the obsolete forward fairing. Specifically, poor enforcement of standard maintenance protocols created an environment that tolerated improper completion of paperwork to ensure parts accountability, severe disorganization at the shop, the improper handling of parts--including a failure to separate serviceable and unserviceable parts, and failure to follow proper procedures for cannibalization (CANN) actions. Given these significant departures from standard protocols, I find that the shop had an environment conducive to failing to follow protocols when ordering and replacing parts.

The Propulsion Flight's poor enforcement of standard maintenance paperwork and accountability protocols is highlighted in one of its Reports of Survey (ROS) that discusses the flight's environment in 2012. During this period, through personal interviews and witness testimony, the Propulsion Flight demonstrated haphazard documentation and parts accountability. The ROS indicates the flight failed to properly document maintenance actions, with one example showing they entered information into a tracking system to indicate a particular Airman removed a part, while also entering information into a separate tracking system indicating that a different Airman removed the same part. This ROS also indicates that a part worth $3K was likely misidentified and turned in for scrap. A second ROS detailing practices from 2013 to 2015 further supports that this Propulsion Flight had a history during 2012 of poor paperwork and accountability, as it discusses a search for $322K worth of parts, most of which eventually turned up on aircraft across the world, without any documentation to show how it left the Propulsion Flight. This ROS also discusses parts that had likely been misidentified and turned in as scrap or sent to headquarters for repair or redistribution. While the second ROS concerns the timeframe immediately following the incorrect ordering and installation of the obsolete fairing, it is reasonable to conclude the same haphazard maintenance procedures that were occurring during this timeframe were holdovers from

2012, based on the similarity of the personnel involved and the descriptions of the Propulsion Flight's environment.

Multiple witnesses detailed the Propulsion Flight's poor enforcement of standard maintenance organization. When one Senior Noncommissioned Officer arrived in 2015, he found the propulsion shop was in disarray, as there were no part shelves, excess parts and boxes were left in the work area, there were old bins of material, and that there were items everywhere without much organization. This deviates from standard protocols since building an engine takes details, parts, and space; and the Propulsion Flight did not have that. It was mix and match, with no standardization of where things went. The shop had their own "method of the madness." Given these departures from standard protocols, the propulsion shop received a half million dollars to revamp the shop, in order to get the shop back up to standards.

The Propulsion Flight's poor enforcement of standard maintenance protocols resulted in improper handling of parts including a failure to separate serviceable and unserviceable parts, and failure to follow proper procedures for cannibalization (CANN) actions. According to the 35 MXS Commander from 2013-2015, the shop was known to have disorganized accountability practices where serviceable and non-serviceable parts were stored in the same area. Additionally, protocols regarding when maintenance personnel can take a serviceable part off of one piece of equipment to use it on another, known as cannibalization (CANN), were not enforced, so CANN procedures were not precise or were happening below the authorized authority level (SNCO) in 2012. The documentation for these actions was also not completed properly. This failure to enforce procedures likely resulted from certain flights having little or no supervision involved in their processes. Further, a report that investigated unaccounted-for parts indicates that a part that should have been carefully tracked was likely misidentified and turned in as scrap metal. A similar report for different items, found that several items were removed and installed on other engines without proper documentation or authorization.

While there is not direct documentation of other incorrectly ordered parts during this time period, the general disarray of the shop, poor parts accountability, the intermingling of serviceable and unserviceable parts, and failure to follow standard protocols (CANN), indicate an environment of poor enforcement of standard maintenance protocols in 2012. Given the strict protocols governing how parts are ordered and installed, a preponderance of the evidence shows the poor enforcement of standard maintenance protocols in 2012 created an environment within the Propulsion Flight that was a substantially contributing factor to the order and installation of the obsolete forward fairing that caused the fire.

4. CONCLUSION

I find by a preponderance of the evidence that the primary cause of the accident was the mishap engine (ME) had an obsolete forward fairing which failed, resulting in an engine fire shortly after takeoff. I further find by preponderance of the evidence that the haphazard maintenance practices in the Propulsion Flight during the 2012 period substantially contributed to the mishap where rescinded forward fairing parts were ordered by the Propulsion Flight's (JEIM) section and installed on the ME.

24 July 2018

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