UNITED STATES AIR FORCE AIRCRAFT ACCIDENT INVESTIGATION BOARD REPORT

F-16C, T/N 90-0755

314TH FIGHTER SQUADRON
49TH WING
HOLLOMAN AFB, NEW MEXICO

LOCATION: HOLLOMAN AFB, NEW MEXICO

DATE OF ACCIDENT: 29 OCTOBER 2019

BOARD PRESIDENT: COLONEL JOEL R. DEBOER

Conducted IAW Air Force Instruction 51-307

EXECUTIVE SUMMARY
UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION

F-16, T/N 90-0755
HOLLOMAN AIR FORCE BASE, NEW MEXICO
29 OCTOBER 2019

On the evening of 29 October 2019, a flight of three F-16 aircraft departed Holloman Air Force Base (AFB), New Mexico (NM) at 1826 hours local (L) for a routine night training mission. At approximately 1906L, the Mishap Aircraft (MA), an F-16C Block 42, tail number (T/N) 90-0755, assigned to the 314th Fighter Squadron at Holloman AFB, NM, crashed on privately-owned land approximately 95 miles southeast of Holloman AFB. The aircraft, valued at $24,229,944, was completely destroyed upon impact. The Mishap Pilot (MP) ejected safely and was recovered by a United States Army helicopter from Fort Bliss, Texas. Holloman AFB personnel conducted the environmental remediation of the crash site.

The mishap mission was scheduled as an instructor continuation training sortie to maintain night vision goggle low-altitude navigation currency. The Mishap Flight (MF) was appropriately planned on a local low-level instrument route flying over southern New Mexico and western Texas. All members of the MF were instructor pilots and were current and qualified in all elements of the mission. Approximately 40 minutes after takeoff, the MA, while flying the number three position in a trail formation, experienced catastrophic engine failure resulting in an uncontrollable engine fire at low altitude leading to the MP's decision to abandon the aircraft.

The Board President found, by a preponderance of the evidence, the mishap was caused by the catastrophic failure of the engine resulting from the failure to install the 1st Stage Rear Air Seal during overhaul of the engine's Inlet Fan Module by depot-level maintenance personnel at Tinker AFB, Oklahoma in September 2016. Without the 1st Stage Rear Air Seal, the 2nd Stage Fan Blades eventually migrated forward until the excessive strain of operation resulted in the liberation of 2nd Stage Fan Blades, leading to a significant loss of thrust, and an uncontained engine fire fueled by a perforated A-1 fuel tank. Additionally, the Board President found the following factors, which occurred at the depot-level maintenance, substantially contributed to the mishap: unqualified and untrained maintenance personnel, lack of supervision, and negligent procedural practices. The failure to install the 1st Stage Rear Air Seal resulted from a failure to follow checklist procedures by an unqualified and untrained mechanic who was not under the immediate supervision of a trainer. The failure was compounded by the mechanic trainee continuing assembly to a point where proper installation could no longer be verified, yet both the Depot Maintenance Trainer (DMTr) and Depot Maintenance Employee (DME) stamped completion anyway. Therefore, I find the DMTr, DME, and Depot Maintenance Trainee were all causal to the mishap.

SUMMARY OF FACTS AND STATEMENT OF OPINION
F-16, T/N 90-0755
29 OCTOBER 2019

TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS

AAI	Air-to-Air Interrogator
AB	After Burner
AC	Alternating Current
ACES	Advanced Concept Ejection Seat
ACI	Analytical Component Inspection
ACMI	Air Combat Maneuvering Instrumentation
ACT	Actuator
ACTL	Adhesives & Composites Team Lead
ADG	Accessory Drive Gearbox
ADI	Attitude Direction Indicator
AETC	Air Education and Training Command
AETCCC	Air Education and Training Command Commander
AFLCMC	Air Force Life Cycle Management Center
AFRL	Air Force Research Lab
AFSAS	Air Force Safety Automated System
AF	Air Force
AFB	Air Force Base
AFE	Aircrew Flight Equipment
AFI	Air Force Instruction
AFIP	Air Force Institute of Pathology
AFPAM	Air Force Pamphlet
AFSC	Air Force Specialty Code
AFSECO	Air Force Safety Observer
AFTO	Air Force Technical Order
AGCAS	Automatic Ground Collision Avoidance System
AGL	Above Ground Level
AHAS	Avian Hazard Advisory System
AIB	Accident Investigation Board
A/L	Aft/Left
ALT	Altitude
AMD	Acceleration Monitoring Device
AMUX	Avionics Multiplex
AOA	Angle of Attack
AP	Area Planning
A&P	Airframe and Powerplant
ASSY	assembly
ATAGS	Advanced Tactical Anti-G System
ATA	Actual Time of Arrival
ATC	Air Traffic Control
ATD	Actual Time of Arrival
AUX	Axillary
AWACS	Airborne Warning and Control System
BARO	Barometric
BASH	Bird/wildlife Aircraft Strike Hazard
BEAR	Basic Expeditionary Airfield Resources
BLD	Blade
BOM	Bill of Materials
BRAG	Breathing Regulator/Anti-G
BRG	Bearing
BSA	Basic Surface Attack
B/V	Bypass Valve
C	Centigrade
CADC	Central Air Data Computer
CAF	Combat Air Force
CAPS	Critical Action Procedures
Capt	Captain
CARA	Combined Altitude Radar Altimeter
CARB	Canopy Actuator Release Bolt
CAS	Close Air Support
CAUT	Caution
C/A.S	Compressor Air Seal
CCM	Coil Current Monitor
CD	Condition
C/DSK	Compressor Disk
CEMS	Comprehensive Engine Management System
CHUM	Chart Updating Manual
CII	Configuration Item Identification
CIP	Core Integrated Processor
CIIV	Compressor Inlet Variable Vane
CJRM	Canopy Jettison Rocket Motors
Col	Colonel
COM	Communication
COMPR	Compressor
CONT	Control
CONV	Convergent
CPR	Compressor

CPRST Compressor Stator
CSD Constant Speed Drive
CSFDR Crash Survivable Flight Data Recordings
CSMU Crash Survivable Memory Unit
CT Continuation Training
CT Combat Time
CTAF Common Traffic Advisory Frequency
C/W Complied With
CYL Cycle
CYLIND Cylinder
DBTC Database Terrain Cueing
DC Direct Current
Deg Degrees
DFL Dry Film Lubricant
DFLCC Digital Flight Control Computer
DFLCS Digital Flight Control System
DIA Diameter
DME Depot Maintenance Employee
DMS Depot Maintenance Supervisor
DMTe Depot Maintenance Trainee
DMTr Depot Maintenance Trainer
DNIF Duty Not Including Flying
DoD Department of Defense
DOS Director of Safety
DRS Digital Recovery Sequencer
DSJA Deputy Staff Judge Advocate
DSK Disk
DTA Detonation Transfer Assembly
DTC Data Transfer Cartridge
DTS Digital Terrain System
DUR Depot Union Representative
DVR digital video recording
ECRL Emergency Canopy Release Lines
ECS Environmental Control System
EDNA Enhanced Diagnostic Aid
EDS Energy-Dispersive Spectroscopy
EDU Engine Diagnostic Unit
EEMTL Electrical & Electronic Materials Team Lead
EFB Electronic Flight Bag
EFH engine flight hours
EFT Engine Flight Time
EGI Embedded Global Positioning System/Inertial Navigation System
EI Engine Investigator
ELT Emergency Locator Transmitter
ENG Engine
EOR End of Runway
EOS Emergency Oxygen System
EOT Engine Operating Time
EP Examiner Pilot
EPE Emergency Procedure Examination
EPS Emergency Power Supply
EPU Emergency Power Unit
ER Emergency Room
ERRC Engine Regional Repair Center
ES Equipment Specialist
ESD Electrostatic Discharge
EST Estimated
ETA Estimated Time of Arrival
ETD Estimated Time of Departure
ETR External Time Reference
EVAL Evaluator
F Fahrenheit
FCIF Flight Crew Information File
FDT Fan Drive Turbine
FG Fighter Group
FIBERGLS Fiber Glass
FL Flight Lead
FLCS Flight Control System
FLT Flight
FO Foreign Object
FP Flight Profile
FP Functional Pilot
FPM Feet Per Minute
F/R Front/Right
FPS Fire Protection System
FRC Fault Reporting Codes
FRT Front
FS Fuselage Station
FS Flight Surgeon
FS Fighter Squadron
ft Feet
FTIT Fan Turbine Inlet Temperature
FTU Flight Training Unit
FW Fighter Wing
FWD Forward
FREQ Frequency
g Gravitational Force
Gal galling

GK	General Knowledge
GPS	Global Positioning System
GTIMS	Graduate Training Integration Management System
GV	General Vehicle
H70	70% Solution Hydrazine
h:m:s	Hours:Minutes:Seconds
HAFB	Holloman Air Force Base
HFACS	Human Factors Analysis and Classification System
HMCS	Helmet Mounted Cuing System
HPC	High Pressure Compressor
HPT	High Pressure Turbine
HQ	Headquarters
HR	hour
HSNG	Housing
HUD	Heads-Up Display
HTR	Heater
HYD PR	Hydraulic Pressure
Hz	Hertz
IAW	In Accordance With
ICAWS	Integrated Caution, Advisory and Warning System
IFDL	Intra-Flight Data Link
IFM	Inlet Fan Module
IFOC	in flight ops check
IGV	Inlet Guide Vane
IMC	Instrument Meteorological Conditions
IMDS	Integrated Maintenance Data System
IMIS	Integrated Maintenance Information System
INIT	Initial
INL	Inlet
INSP	Inspection
INSTM/QUAL	Instrument Qualification i.e. "check ride"
INSTR	Instructor
IO	Investigating Office
IP	Instructor Pilot
IPF	Interference Protection Features
IPUG	Instructor Pilot Upgrade
IR	Instrument Route
IR	Instrument Rating
ISA	Integrated Servo Actuators
ISB	Interim Safety Board
ITN	Internal Tracking Number
IVSC	Integrated Vehicle Subsystem Controller
JA	Legal Representative
JDAM	Joint Direct Attack Munitions
JFS	Jet Fuel starter
JG	Job Guide
JMPS	Joint Mission Planning System
JSECTS	Joint Services Combat Systems Tester
K	Thousand
KBIF	Biggs Army Airfield
KCAS	Knots Calibrated Airspeed
KHMN	Holloman Air Force Base
KIAS	Knots Indicated Airspeed
KTAS	Knots True Airspeed
kts	Knots
L	Local Time
L	Left
LANTIRN	Low Altitude Navigation & Targeting Infrared for Night
LE	Leading Edge
LEF	Leading Edge Flap
LFE	Large Force Exercise
LHT	Left Horizontal Tail
LIMFAC	Limiting Factor
LL	Low Level
LM	Lockheed Martin
LMFSE	Lockheed Martin Flight Safety Investigator
LOA	Loss of Aircraft
LOC	Location
LOWAT	Low Altitude Training
LPC	Low Pressure Compressor
LPT	Low Pressure Turbine
LRA	Last Rework Activity
LST	List
LT	Light
Lt Col	Lieutenant Colonel
LWD	Left Wing Down
M	Mach
MA	Mishap Aircraft
Maj	Major
MAJCOM	Major Command
MDS	Aircraft Mission-Design Series

MDT	Mishap Depot Technician
ME	Mishap Engine
MEF	Mission Execution Forecast
MF	Mishap Flight
MFD	Multifunctional Display
MFL	Maintenance Fault List
MFL	Mishap Flight Lead
MGT	Management
MIBC	Materials Integrity Branch Chief
MIBDC	Materials Integrity Branch Deputy Chief
MIDS	Multifunction Information Distribution System
MIL	Military Power
MLG	Main Landing Gear
mlux	millilumens
MMC	Modular Mission Computer
MNCL	Master Nuclear Certification list
MOA	Military Operating Area
MP	Mishap Pilot
MPE	Material Process Engineering
MS	Mishap Sortie
MSL	Mean Sea Level
MSN	Mission Check Ride
MW	Mishap Wingman
NAVAID	Navigational Aid
ND	Nose Down
NM	New Mexico
No.	Number
NOTAMs	Notices to Airmen
NSTL	Not Stock Listed
NTR	Network Time Reference
NU	Nose Up
NUM	Number
NVG	Night Vision Goggles
OC	Oklahoma City
OCA	Offensive Counter Air
OCT	operating cycle time
OFP	Operational Flight Program
OG	Operations Group
OHEAT	Overheat
OI	Operating Instruction
OJT	On the Job Training
OPR	Officer Performance Report
Ops Tempo	Operations Tempo
ORM	Operational Risk Management
OSS	Operation Support Squadron
OVHL	Overhaul
PA	Public Affairs
PAC	Production Acceptance Certification
PAO	Polyalphaolefin
PARS	Pilot Activated Recovery System
PCS	Permanent Change of Station
PDN	Part Discontinuance Notice
PE	Personal Evaluation
PE	Project Engineer
PFI	Propulsion Flight Instructor
PFL	Propulsion Flight Lead
PHA	Physical Health Assessment
PLF	Parachute Landing Fall
PLS	Plans and Scheduling
PME	Professional Military Education
PMP	Packaged Maintenance Plan
PMXG	Propulsion Maintenance Group
PMXS	Propulsion Maintenance Squadron
P/N	Part Number
P.O.	Program Order
pph	Pounds Per Hour
PR	Pre Flight
PRI	Primary
PS	Power Switch
PSA	Propulsion System Analysis
PSI	Pounds Per Square Inch
Pubs	Publications
P&W	Pratt and Whitney
PWCE	Pratt & Whitney Chief Engineer
PWCR	Pratt & Whitney Contractor Representative
PWCSE	Pratt & Whitney Customer Support Engineer
PWE	Pratt & Whitney Employee
PWFS	Pratt & Whitney Flight Safety
PWFSI	Pratt & Whitney Flight Safety Investigator
PWL	Pratt & Whitney Lead
PWMEFS	Pratt & Whitney Military Engines Flight Safety
PWMM	Pratt & Whitney Model Manager
PWMPE	Pratt & Whitney Materials and Processing Engineer
QA	Quality Assurance
QC	Quality Check

QDR	Quality Deficiency Report
QTY	quantity
Qual	Qualification
R	Right
RALT	Radar Altimeter
RAP	Ready Aircrew Program
R/A.S.	Rear Air Seal
RCC	Regional Control Center
RECOND	Reconditioned
REQ	Required
RESCIND	Rescission Date
RET	Retainer
RHT	Right Horizontal Tail
RNAV	Area Navigation
RNET	Report No Earlier Than
RPM	Revolutions Per Minute
RTB	Return-To-Base
RWD	Right Wing Down
RWR	Radar Warning Receiver
S/N	Serial Number
SADL	Situational Awareness Data Link
SAN	Surface Attack Night
SAR	Search and Rescue
SAT	Surface Attack Tactics
SAU	Signal Acquisition Unit
SCU	Software Capability Upgrade
SDR	Seat Data Recorder
SDRI	Seat Data Recorder Interface
SE	Set
SEAD	Suppression of Enemy Air Defenses
Sec	Second
SEC	Secondary flight time
SEFE	Standardization and Evaluation Flight Evaluator
SEN	Sensor
SEPT	Safety and Emergency Procedures Training
SERV	Servicing
SFO	Simulated Flame-out
SIB	Safety Investigation Board
SII	Special Interest Item
SIM	Simulator
SJA	Staff Judge Advocate
SKL CD	Skill Code
SOF	Supervisor of Flying
SORT	Sortie
Spd	Speed
SFC	Surface
SKC	Skies Clear
SM	Statue Miles
SMETL	Structural Materials Evaluation Team Lead
SMETM	Structural Materials Evaluation Team Member
SRS	Shoulder Restraint Specialist
SS	System Status
SWP	Sub Work Package
STAPAC	Pitch Stabilization Control Assembly
STA	Station
STG	Stage
STK	Stock
SUB OP	Sub Operation
SV	Electro-Hydraulic Servo Valves
SYN	Sync
TACAN	Tactical Air Navigation System
TAF	Terminal Area Forecast
TAS	True Airspeed
TCTO	Time Compliance Technical Order
TDOP	Teledyne Director of Programs
TDRM	Trajectory Divergence Rocket Motor
TE	Trailing Edge
TE	Technical Expert
TEC	Temporary Engineering Change
TF	Terrain Following
TI	Titanium
TM	Type Maintenance
T/N	Tail Number
TO	Technical Order
TOD	Tech Order Data
TS	Top Secret
TSN	Time Since New
TT	Total Time
UHF	Ultra High Frequency
USAFA	United States Air Force Academy
USAFE	United States Air Forces Europe
UWARS	Universal Water Activated release
VAC	Volts Alternating Current
VDC	Volts Direct Current
VDO	Vault Duty Officer
VFR	Visual Flight Rules

VHF	Very High Frequency
VMC	Visual Meteorological Conditions
VRLVN	Variable Vane
VVI	Vertical Velocity Indication
WB	Witness Bystander
WCD	Work Control Document
Wg	Wing
WOW	Weight-On-Wheels
WP	Work Package
WSMR	White Sands Missile Range
WX	Weather
XRF	X-Ray Fluorescence
Z	Zulu

SUMMARY OF FACTS

1. AUTHORITY AND PURPOSE

a. Authority

On 1 November 2019, Lieutenant General Marshall B. Webb, the Commander of Air Education and Training Command (AETC), appointed Colonel Joel R. DeBoer to conduct an Accident Investigation Board (AIB) for a mishap that occurred on 29 October 2019, involving an F-16C aircraft, tail number (T/N) 90-0755, approximately 95 miles southeast of Holloman Air Force Base (AFB), New Mexico (NM) (Tabs K-7, L-141, and Y-3 to Y-4). The investigation was conducted at Holloman AFB, NM from 6 January 2020 through 31 January 2020. Additionally, the following members were appointed to support the accident investigation: a Colonel medical member, a Major pilot member, a Major legal advisor, a Master Sergeant engine technician, a Technical Sergeant recorder, and a Senior Airman maintenance member (Tab Y-5 to Y-8).

b. Purpose

In accordance with Air Force Instruction (AFI) 51-307, *Aerospace and Ground Accident Investigations*, this AIB 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

On the evening of 29 October 2019, the Mishap Aircraft (MA), an F-16C Block 42, T/N 90-0755, operated by the 314th Fighter Squadron (FS), 54th Fighter Group (FG), departed Holloman AFB at 1826L for a routine low-altitude night vision goggle (NVG) navigation continuation training (CT) mission over southern New Mexico and western Texas on instrument route (IR) 192 (Tabs CC-14, G-5, O-4 to O-5, and R-1.4 to R-1.5). The Mishap Flight (MF) consisted of a flight of three F-16C aircraft with the MA flying the number 3 position (Tab R-1.5). At 1905L, while on IR-192 between points "P" and "Q" and while flying in sensor trail formation of approximately 2-3 miles separation between each aircraft, the MA experienced catastrophic engine failure resulting in an uncontrollable engine fire (Tabs J-4 to J-8, O-4, R-2.5 to 2.6, and R-2.32). The Mishap Pilot (MP) was able to successfully eject before the MA impacted the ground, and the aircraft, valued at $24,229,944, was completely destroyed (Tabs J-52, I-6, and R-1.8 to R-1.9). The crash site was located on privately-owned, desert land approximately 95 miles southeast of Holloman AFB (Tabs L-141 and S-14).

3. BACKGROUND

a. Air Education and Training Command (AETC)

AETC's mission is to recruit, train and educate exceptional Airmen (Tab CC-3). AETC, with headquarters at Joint Base San Antonio-Randolph, Texas, was established and activated in January 1942, making it the second oldest major command in the Air Force (Tab CC-3). AETC includes Air Force Recruiting Service, two numbered air forces and the Air University (Tab CC-4).

The command has more than 29,000 active-duty members, 6,000 Air National Guard and Air Force Reserve personnel, and 14,000 civilian personnel (Tab CC-4). AETC also has more than 9,000 contractors assigned (Tab CC-4). AETC has approximately 1,400 aircraft operating flights at 12 major installations and supports tenant units on numerous bases across the globe, encompassing 16 active-duty and seven Reserve wings (Tab CC-4).

b. 49th Wing (49 Wg)

The 49th Wing's mission is to build the backbone of combat airpower by producing operationally-ready F-16 and MQ-9 aircrew; deploying combat-ready forces; and enabling Basic Expeditionary Airfield Resources (BEAR) base, Test Group and other mission partners to succeed. (Tab CC-12) The wing trains MQ-9 Reaper pilots and sensor operators and F-16 Fighting Falcon pilots (Tab CC-12). The 49th Wing, through the 49th Maintenance Group, maintains F-16 aircraft operated by the 314 FS (Tab CC-12 to CC-13).

c. 314th Fighter Squadron (314 FS)

The 314 FS operates under the 54 FG, assigned to the 49th Wing, at Holloman AFB (Tab CC-13 to CC-14). The 314 FS's mission is to produce world class F-16 pilots for the combat air forces (Tab CC-16).

d. F-16 Fighting Falcon

The F-16 Fighting Falcon is a single-engine, multi-role jet fighter built by Lockheed Martin Corporation (Tab CC-17 to CC-18). In air-to-air combat, the F-16's maneuverability and combat radius exceed that of all potential threat fighter aircraft (Tab CC-17) In its air-to-surface role, the F-16 can fly more than 500 miles, acquire its target in all weather conditions, defend itself against enemy aircraft, and return to its starting point (Tab CC-17) The F-16 can reach speeds up to Mach 2 (Tab CC-18). The F-16C is the modern, single-seat variant of this proven and versatile aircraft (Tab CC-18).

e. Oklahoma City Air Logistics Complex

The Oklahoma City Air Logistics Complex, Tinker Air Force Base, Oklahoma, is one of the largest units in the Air Force Materiel Command, with a team of over 9,800 military and civilian professionals delivering combat power for America (Tab CC-20). The complex performs programmed depot maintenance and modifications on KC-135, B-1B, B-52, E-3 and Navy E-6 aircraft; conducts maintenance, repair and overhaul for F100, F101, F108, F110, F117, F118, F119, F135, TF33 engines; and repairs a wide variety of commodities for the Air Force, Navy, Marine Corps, and foreign military sales (Tab CC-20 to CC-21). The complex's 76th Propulsion Maintenance Group (PMXG) is the Department of Defense's foremost engine repair and overhaul center (Tab CC-21). The 76th PMXG performs repairs on various engines and engine assemblies, including the F100 and F110 engines utilized in F-16 fighter aircraft (Tab CC-18 and CC-21).

4. SEQUENCE OF EVENTS

a. Mission

On Tuesday, 29 October 2019, the 314 FS scheduled and authorized the MF's mission as a three-ship formation conducting a NVG low-altitude navigation CT sortie (Tabs K-4 to K-5 and AA-4 to AA-5). The sortie was flown solely for IP training and currency with no student syllabus or upgrade training planned or accomplished (Tab R-1.4 to R-1.5).

b. Planning

The MP arrived at the 314 FS at 1215L for mission planning (Tab R-1.26). The MP was originally scheduled to lead a two-ship, instructor-only CT sortie (Tab R-1.4 to R-1.5). Approximately one hour prior to brief time, the MP's wingman fell ill and was unable to fly (Tab R-1.5 and R-3.7). As a result, the MP was rescheduled to fly as number three in another instructor-only CT mission (Tab R-1.5). The MF members accomplished all required mission planning for their sortie for IR-192 (Tab R-1.5, R-2.5, and R-3.4). Mission planning included, but was not limited to, checking notices to airmen (NOTAM) for all applicable airfields, navigational aids and controlling agencies; scheduling IR-192 with the controlling agency; checking the bird-strike hazard status via the Avian Hazard Advisory System (AHAS); reviewing weather for all applicable airfields and IR-192; confirming night illumination data; and preparing required flight materials (Tab R-1.5, R-2.5, and R-3.4). Of note, the weather was not forecasted to be a factor for the flight, the bird status was low for the majority of the route and the illumination data revealed high illumination until 1930L (Tabs F-2, F-6, and O-3). All three pilots completed an operational risk management (ORM) form, which is used to rate the level of risk for the particular flight, and was signed off by the appropriate level of supervision based on the risk level (Tab AA-5). The MP's ORM was rated as low risk (Tab AA-5).

c. Preflight

At 1550L, the mishap flight lead (MFL) conducted the flight briefing and covered all required items for the sortie during the allotted brief time (Tab R-2.5, R-2.13, and R-2.14). The mishap flight members stepped to their respective jets at approximately 1725L, started engines at 1740L, and taxied at 1755L (Tab O-5). The MFL's aircraft was configured with a centerline external fuel tank, training air-to-air missiles and an air combat maneuvering instrumentation (ACMI) pod (Tab AA-4). The Mishap Wingman's (MW) and MP's aircraft were both configured with air-to-air training missiles and an ACMI pod (Tab R-1.5, AA-4). Throughout the planning and preflight portion, the pilots noted no significant abnormalities and viewed their mission preparation time as sufficient (Tab R-1.11, R-2.5, R-2.10, and R-3.18).

d. Summary of Accident

At 1826L, the MF departed Holloman AFB on a radar-assisted trail departure in which each subsequent aircraft maintained 2-3 miles separation (Tabs O-5, R-2.5 to R-2.6, R-2.32 and BB-4 to BB-5). The MF departed to the northeast, entered IR-192 and flew the first 16 points of the route without incident (Tab R-1.6, R-2.6, R-2.15 and R-3.5).

Between points "P" and "Q", the MP felt a significant loss of thrust followed by the near simultaneous illumination of the engine fire light, engine overheat light and engine light with associated high engine temperatures (Tabs J-6, O-4, R-1.6 to R-1.7, and R-2.6). The MP retarded the throttle to Idle and started a slight climb (Tabs J-6 and R-1.7). Simultaneously, the MP made a call on the Very High Frequency (VHF) radio to cease tactical maneuvering (Tab R-1.7). This radio call was not heard by the MFL and MW, mostly likely due to the momentary power disruption during engine spool down as the main and standby generators fell offline and the emergency generator being not yet operational (Tabs J-9 to J-10, R-1.8, R-2.6, and R-3.5). Engine rollback and fire indications continued, and the MP applied the airstart procedures by placing the throttle to Off and then back to Idle (Tab R-1.7).

At approximately 1906L, with the MA's engine not recovering and the MP noticing a glow from the engine fire behind him, the MP continued climbing, made a radio call on the Ultra High Frequency (UHF) radio saying "three's getting out, three's getting out," and subsequently ejected (Tabs J-7, R-1.8, and R-1.16 to R-1.17). Upon hearing the MP's UHF transmission, the MFL and MW commenced a turn toward the MP's location (Tab R-2.6). During the turn, the MFL noticed the MA was on fire prior to impacting the ground, which was confirmed by Witness Bystander (Tab R-2.6 and R-4.2).

e. Impact

The MA impacted the ground in a dry lakebed, approximately 95 miles southeast of Holloman AFB and was destroyed (Tabs I-6, J-4, and L-141).

f. Egress and Aircrew Flight Equipment (AFE)

The MP ejected safely at 200 knots ground speed and 6,500 feet mean sea level (MSL), which was approximately 2,200 feet above ground level (AGL) (Tabs J-4 and R-1.8). An Air Force Life Cycle Management Center comprehensive evaluation of all components of the ejection sequence showed the ejection event was successful with only minor issues identified (Tab J-63 to J-64). According to the report, the minor issues did not affect the MP's ejection sequence (Tab J-63 to J-64).

g. Search and Rescue

The MFL and MW immediately began orbiting over the location of the MA's impact and contacted an Air Traffic Controller (ATC) at Albuquerque Center to begin search and rescue efforts (Tab R-2.6 to R-2.7). A few minutes after ejection, the MP made radio contact with the MFL, confirmed the MP's physical condition (minimal injuries), identified the MP's approximate location, and gathered coordinates to pass to search and rescue assets (Tab R-2.7 to R-2.8). Albuquerque Center contacted Holloman Command Post and started the process of getting search and rescue assets to the MP's location (Tab R-2.8). The MFL and MW remained over the MP's location until they passed on-scene commander duties to another flight of four F-16s from Holloman AFB prior to returning to base (Tab R-1.10 and R-2.9). The MP was on the ground for approximately an hour and a half before search and rescue assets from Biggs Army Airfield could reach the MP's location (Tab AA-15). Once the UH-60 helicopter arrived, the recovery and transportation of the MP to the local regional military trauma medical center occurred without incident (Tab R-1.11).

h. Recovery of Remains

Not applicable.

5. WING-LEVEL MAINTENANCE

a. Forms Documentation

Collectively, the Air Force Technical Order (AFTO) 781-series forms capture maintenance actions, inspections, servicing, configuration, current status, and flight activities for an aircraft (Tab D-2 to D-24).

The Integrated Maintenance Data System (IMDS) is an electronic database used to track maintenance actions, flight activity, schedule future maintenance and serve as a collective history of maintenance actions (Tab U-69).

Upon review of the aircraft AFTO 781 forms and IMDS, there were no overdue inspections or open Time Compliance Technical Orders (TCTO) that would prohibit the MA from flight operations (Tab D-16 to D-23). IMDS data review, covering a 180-day period prior to the mishap, showed maintenance was properly documented in accordance with (IAW) applicable directives (Tab U-69). The MA had no significant repeating nor recurring maintenance issues (Tab U-69). The maintenance forms contained only one discrepancy in that the MA was released for flight earlier on 29 October 2019; however, the release was voided for a 30-day gun inspection and subsequently needed to be re-released following the inspection (Tab D-9 and D-12). There is no evidence to suggest that this discrepancy was a factor in this mishap.

All required maintenance actions were completed IAW AFTO 00-20-1 *Aerospace Equipment Maintenance Inspection, Documentation, Policies and Procedures* (Tab U-69).

b. Inspections

All the scheduled inspections required for the MA were documented properly IAW applicable technical orders (TO) (Tab D-2 to D-23). On 25 October 2019, qualified personnel performed an inspection of the aircraft's fire and overheat detection system with no discrepancies noted (Tab U-69). On 29 October 2019, maintenance personnel properly completed the preflight and walk-around inspections prior to takeoff IAW 1F-16CG-6 *Combined Preflight/Postflight, End-of-Runway, Thruflight, Launch and Recovery, Alert Inspections, Quick Turnaround, Basic Postflight and Walk-Around Before First Flight of Day Inspection* (Tab D-2 to D-13). The preflight inspections included the following actions:

1) Qualified crew chief completed the required Basic Postflight/Preflight inspection with no discrepancies noted (Tab D-12)

2) Qualified weapons technician completed the Post-Load inspection with no discrepancies noted (Tab D-8).

3) Qualified ground crew personnel completed nitrogen, tire pressure, and aircraft power-on checks with no discrepancies noted (Tab D-8 to D-9).

c. Maintenance Procedures

No evidence indicates any local maintenance procedures contributed to the mishap (Tab D-2 to D-23).

d. Maintenance Personnel and Supervision

No evidence indicates that local maintenance personnel or supervision contributed to the mishap (Tab D-2 to D-23).

e. Fuel, Hydraulic, Oil and Oxygen Inspection Analyses

Post-mishap analysis of the fuel, oil, and oxygen from the local ground support equipment showed no abnormalities (Tab D-25 to D-27). The analysis of hydraulic fluid from the servicing equipment revealed one abnormality in evaporation loss at .5% above tolerances (Tab D-27). No evidence suggests that this abnormality on the hydraulic servicing equipment had any impact on the mishap.

f. Unscheduled Maintenance

Review of local maintenance in the AFTO 781A forms revealed no link between unscheduled maintenance and the mishap (Tab D-2 to D-23).

6. AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS

a. Structures and Systems

(1) Aircraft Condition

Prior to the mishap, the MA was fully mission capable with no discrepancies effecting safety of flight (Tabs D-2 to D-23 and U-69). At the time of the mishap, the MA had 591 hours engine operating time (EOT) since depot-level maintenance on the engine inlet fan module (IFM) (Tabs U-3 to U-67, U-69, and DD-4). Prior to impact, the MA's emergency systems were functioning as intended (Tab J-10).

The aircraft received overwhelming damage upon impacting the ground and during the subsequent post-impact fire (Tab S-4 to S-5). The recovery team retrieved mainly fragmented portions of the MA's airframe and systems, yet portions of the aft fuselage and engine were mostly intact (Tab S-5 to S-6). The right side nacelle ejector barrier and the fire/overheat detection system, which are integral components of the fire protection system, showed burn damage indicative of a fire in flight (Tabs J-8 and Z-3 to Z-4).

(2) Engine

The MA was equipped with a single F100-PW-220 engine – a low bypass ratio, high compression ratio, twin spool turbofan engine with a mixed flow augmentor (Tab DD-3). The engine consists of six major modules: the Inlet Fan Module (IFM); High-Pressure Compressor (HPC); High-Pressure Turbine (HPT); Fan Drive Turbine (FDT), also known as the Low Pressure Turbine (LPT); augmentor; and gearbox (Tab DD-3). The Mishap Engine's (ME) serial number was PW0E703474 and had accrued 4437.8 hours of engine flight time (Tab D-14 and D-15). The ME had 15.1 hours remaining until its next scheduled 100-hour inspection, 18.1 hours until its next scheduled 200-hour engine inspection, and 29.1 hours until its next scheduled 400-hour engine inspection (Tab D-15 and D-23). The ME's last depot-level module overhaul was on the IFM, which was completed in September 2016 (Tab U-3 to U-67).

Figure 1 – F100-PW-220 Diagram (Tab Z-6)

(3) Aft Fuselage

The aft fuselage assembly extends from behind the aircraft's mid-point to the aft end of the fuselage (Tab BB-7 to BB-8). A titanium shield, installed over the hottest section of the engine in the upper aft nacelle cavity, provides temperature protection for the basic aircraft structure and hardware (Tab BB-7 to BB-8). This protective armor plate guards against fuel tank damage in the event of engine fan failure (Tab BB-7).

(4) Fire Protection System

The fire protection system consists of the nacelle ventilation system, fuel tank inerting system, and the engine fire and bleed air overheat detection systems (Tab BB-8). The fire and overheat detection systems provide a means of sensing a fire or overheat condition and displaying a visible warning to the pilot (Tab BB-8). Upon sensing temperatures in the engine compartment exceeding established temperatures, for overheat or fire condition respectively, the system illuminates the appropriate overheat or fire warning lights in the cockpit (Tab BB-8).

(5) Inlet Fan Module

The IFM is the most forward module of the F100-PW-220 turbo fan engine, which includes the 1st, 2nd, and 3rd stage rotors and stators (Tab DD-5 and DD-6).

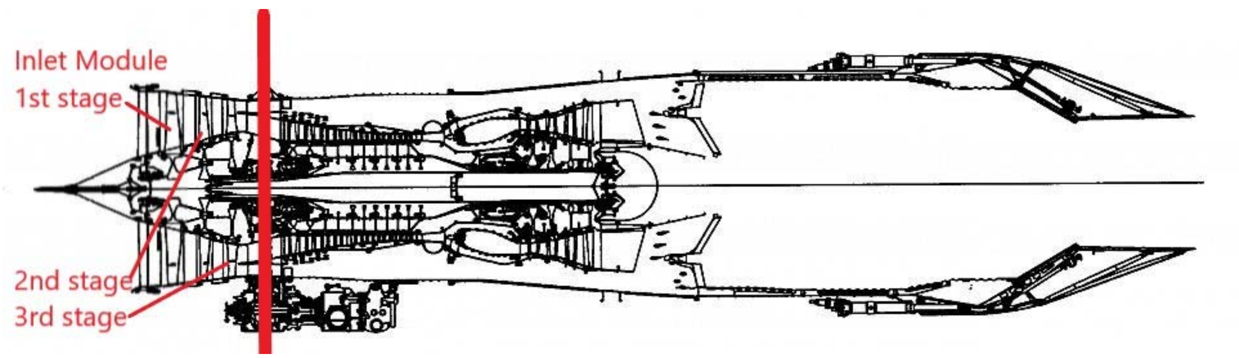

Figure 2 - IFM Diagram (Tab Z-7)

b. Evaluation and Analysis

(1) Fire Protection System

During the mishap, the MP recognized the illumination of the fire warning and engine light (Tab R-1.7). Additionally, the Crash Survivable Flight Data Recorder (CSFDR) indicates the illumination of the engine overheat light near simultaneously with the first indication of an engine malfunction (Tab J-6 and J-8).

(2) Aft Fuselage

The right side of the aft fuselage, which houses electrical harnesses essential to operation of the horizontal stabilizer and flaperon integrated servo actuators (ISA), showed consistent and progressive failure indicative of an inflight fire (Tab J-6 to J-8). Additionally, the aft fuselage heat shielding and the nacelle ejector barrier showed significant fire damage consistent with an inflight fire (Tabs J-8, S-5, and Z-3 to Z-4).

(3) Engine

A post-mishap engine bay analysis by the Air Force Research Laboratory confirmed at least two panels were impacted by metal fragments (Tab J-16 to J-17). The first panel was impacted by fragments of IN-718 alloy, which is found in the 8th thru 11th Stage HPC Blades (Tab J-17). The second panel was impacted by both titanium and stainless steel fragments and had a strong odor of jet fuel likely from penetration of the A-1 fuel cell (Tab J-16 and J-17). The most likely source of the titanium is Ti-8-1-1 (titanium alloy) from either the 1st through 3rd Stage Fan Blades or the 6th Stage HPC Blades (Tab J-17 and J-28). The source of the stainless steel fragment remains undetermined (Tab J-17).

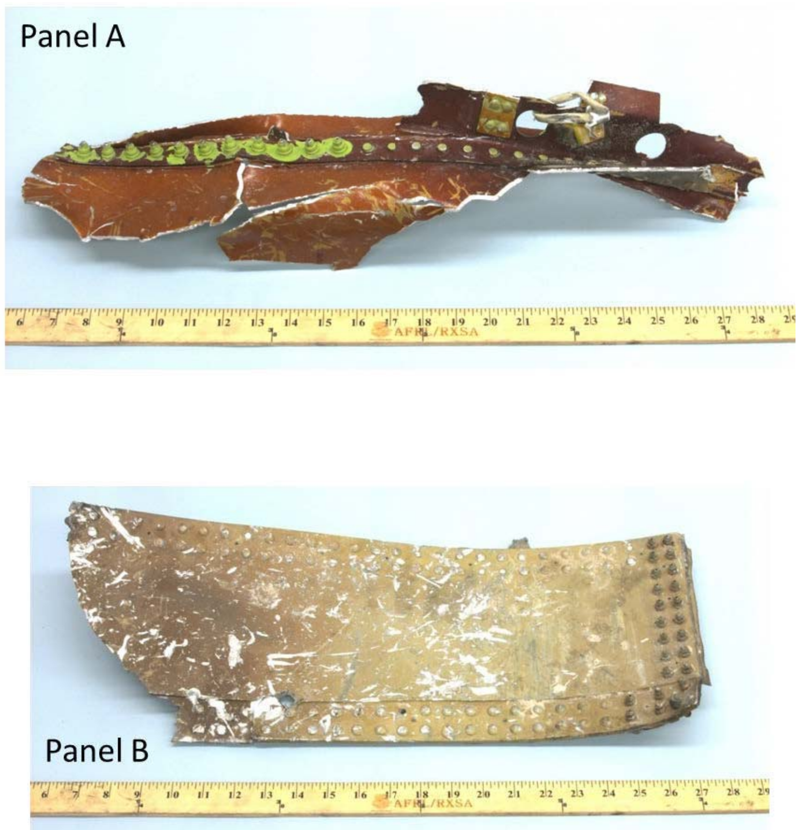

Figure 3 – Impacted MA Panels (Tab J-20)

(4) Inlet Fan Module (IFM)

According to analysis performed by Air Force Life Cycle Management Center and Pratt and Whitney, the recovered IFM demonstrated damage consistent with liberation of the 2nd Stage Fan Blades of which nine were never found (Tab DD-9). Although all other air seals were found in the wreckage, the 1st Stage Rear Air Seal was never recovered (Tab DD-8 to DD-10). There were no apparent witness marks on the 2nd Stage Fan Hub radial interface that mates with the 1st Stage Rear Air Seal (Tabs J-74 and DD-29). The dry lubricant on the mounting holes was undisturbed and had no apparent witness marks on the 2nd Stage Fan Disk Forward Balance Flange from pins and collars that would have been installed during assembly or been forcefully removed during ground impact (Tabs J-74, DD-26, and DD-29 to DD-30). There were no apparent witness marks on the forward face of the 2nd Stage Fan Disk Blade Root Platforms from contact with the 1st Stage Rear Air Seal (Tabs J-74 and DD-30). Additionally, analysis showed the 2nd Stage Fan Blades migrated forward as far as .4 to 1.0 inches (Tabs J-74 and DD-9). The 2nd Stage Fan Disk exhibited multiple lug fractures due to tensile and shear overstresses from the blade forward migration (Tabs J-74, DD-9, and DD-30).

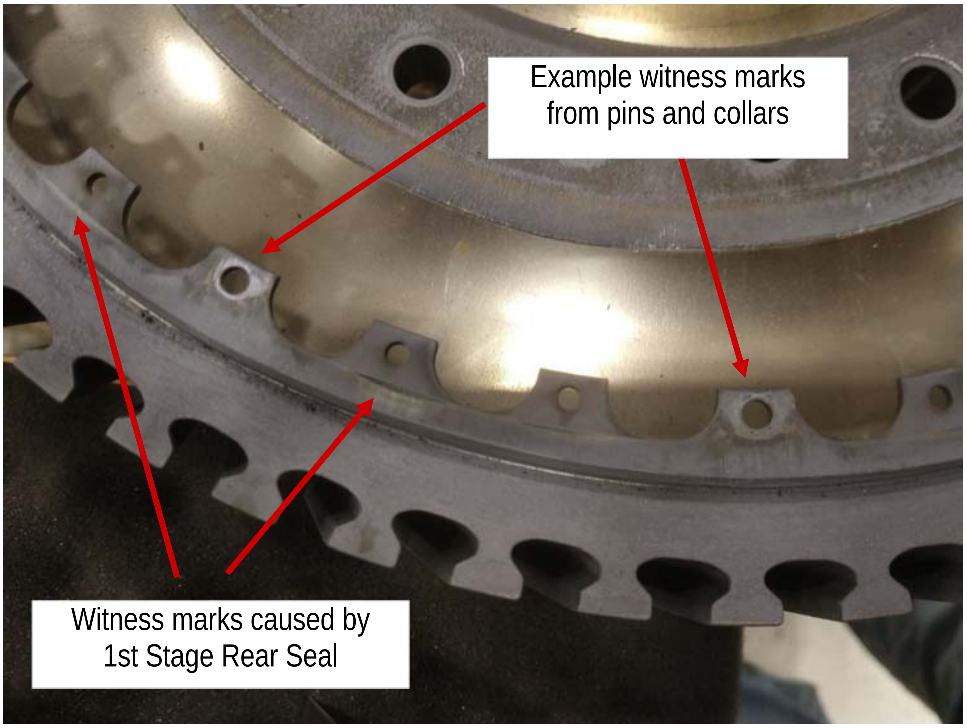

Figure 4 – Example Witness Marks from 1st Stage Rear Air Seal off a normal 2nd Stage Fan Disk Forward Balance Flange [not mishap engine] (Tab J-42)

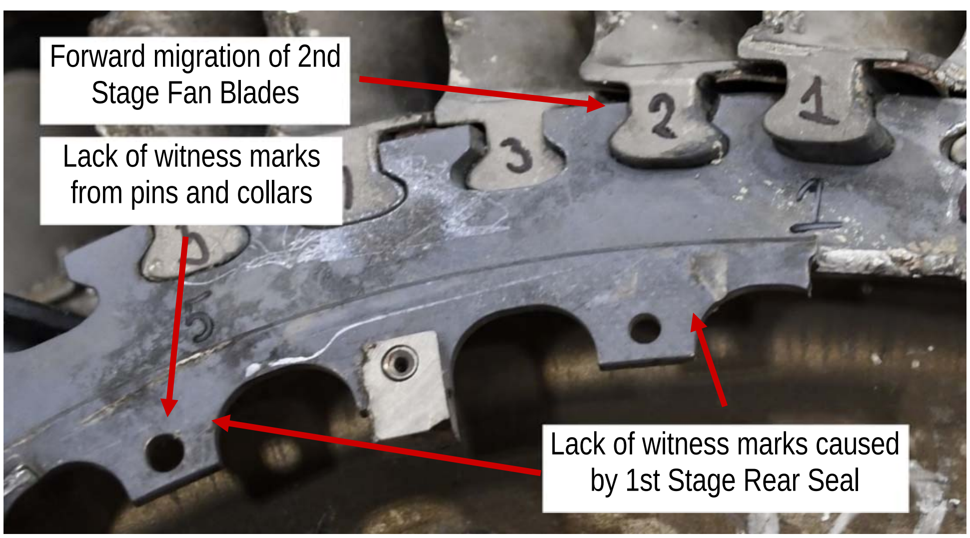

Figure 5 –2nd Stage Fan Disk Forward Balance Flange from Mishap Engine (Tab J-45)

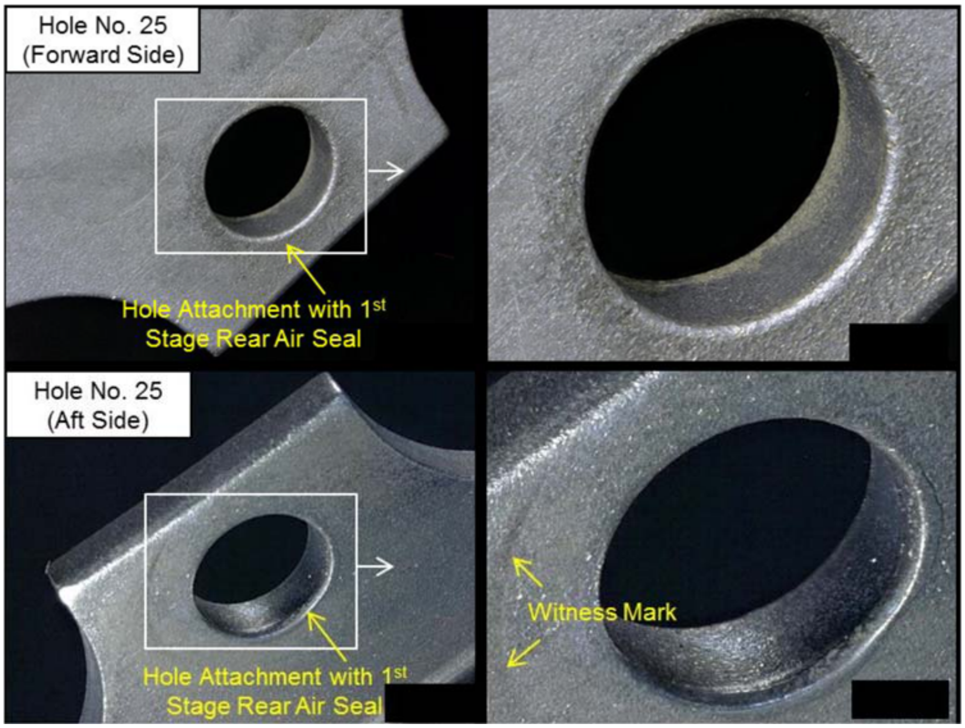

Figure 6 – Undisturbed Dry Film Lubricant and Previous Build Witness Mark Remnants on 2nd Stage Fan Disk Forward Balance Flange from Mishap Engine (Tab DD-26)

(5) Engine Maintenance

An engine becomes due for scheduled inspections when it accrues a specific number of flying hours or Engine Operation Time (EOT), which is tracked by an onboard computer (Tab BB-23). Scheduled inspections consist of a 100, 200, and 400-hour inspections (Tabs D-23 and BB-23). At the time of the mishap, all engine inspections were current (Tab D-23). The technical data for both local flightline and back shop inspections do not call for the verification of the 1st Stage Rear Air Seal due to its obscured location within the module (Tab BB-23). The sole visual verification of the ME's 1st Stage Rear Air Seal was during depot-level IFM overhaul (Tab U-30 and U-31).

(6) Depot Engine Module Maintenance

The engine modules are returned to the engine depot for major repairs or overhaul once reaching a benchmark of cycle time (Tab BB-23). Overhauls are the most extensive scheduled maintenance an engine module undergoes (Tab BB-23). The module is disassembled into its basic components which are subsequently cleaned and inspected (Tab BB-23). If required, the components are refurbished, repaired, or replaced (Tab BB-23).

Prior to module reassembly, the supply holding area collects and records all required module parts and places them on a kit cart (Tabs U-70, V-2.29, V-3.12 to V-3.13, V-4.5, V-4.16, and V-5.1). The kits are distributed to the mechanics for assembly (Tabs U-70, V-2.29, V-3.12 to V-3.13, V-4.5, and V-4.16). The IFM assembly begins with the installation of weight-matched sets of fan blades into the disks by interlocking the mid-span shrouds and tapping blades gently into place, followed by the applicable air seals, creating a rotor assembly for each stage (Tabs U-3 to U-67, V-2.12 to V-2.13, V-4.6, and BB-23). Of note, the 1st Stage Rear Air Seal is installed on the front face of the 2nd Stage Fan Disk and acts as a retainer for the 2nd Stage Fan Blades (Tabs U-30 to U-31 and DD-8 to DD-9).

At stacking, stator cases are sequentially installed around the corresponding rotor assembly (Tabs U-47 to U-53, V-2.7 to V-2.10, and V-5.2). After stacking, the combined rotating assembly is balanced (Tab U-53 to U-62). Once balancing is complete, all remaining components are installed to complete module assembly (Tabs U-3 to U-26 and V-4.5). The 1st Stage Rear Air Seal is only accessible and visible until the installation of the 2nd Stage Stator Case during stacking (Tabs U-30 to U-66, V-3.20, and V-4.19).

A work control document (WCD) synopsizes and documents each step of module assembly (Tabs U-3 to U67 and BB-9 to BB-11). The maintenance mechanic verifies and documents completion of each step on the WCD utilizing their individualized stamp (Tabs U-3 to U67, V-2.6, V-3.4, V-4.4 to V-4.5, and BB-13). According to section 7.4.6.3 of Air Force Sustainment Center Manual 21-102_OC-ALCSUP, *Depot Maintenance Management*, some crucial steps require an additional or secondary buy-off, aside from the member performing the maintenance, who verifies the work was completed properly and also stamps the WCD (Tabs U-30, V-2.14, V-3.9, V-4.7, V-4.10, and BB-13). During OJT, the trainee performing the maintenance will stamp the far right side of the step and the trainer will stamp the certification box (Tab U-30, V-2.14, and V-3.4 to V-3.5). Per Air Force Sustainment Center Manual 21-102, *Depot Maintenance Management*, use of these individualized maintenance stamps is mandatory "to certify, by stamping and dating, the work has been accomplished and completed as required by specified technical data." (Tab BB-9 to BB-11)

The WCD for the mishap IFM indicates the Depot Maintenance Trainee (DMTe) built the 2nd and 3rd Stage Compressors and Rotor Assemblies by placing the blades onto the compressor hub and assembled, or "stacked," the rotors and stators for the 1st and 2nd Stages of the IFM (Tab U-29 to U-30, U-41 to U-51). During construction of the 2nd Stage Rotor, the part and serial numbers for the 2nd Stage Air Seal were improperly documented in place of the 1st Stage Rear Air Seal, which is physically impossible to install in that location (Tabs U-30 to U-31, V-3.15, and V-4.13 to V-4.14). These actions were signed off by the DMTe on 18 September 2016, but the work was not verified by the Depot Maintenance Trainer (DMTr) until 19 September 2016 (Tab U-30 to U-31). Additionally, the Depot Maintenance Employee (DME) did not conduct the second "buy off" until 19 September 2016 (Tab U-30). Several witnesses confirmed the 1st Stage Rear Air Seal would not be visible after installation of the 2nd Stage Fan Case (Tab V-3.20 and V-4.19).

7. WEATHER

a. Forecast Weather

The 49th Wing weather forecasters provided the mission execution forecast (MEF) for local flights to the surrounding training areas and ranges (Tab F-2 to F-4). On the night of the mishap, the forecasted weather for takeoff and low-level route IR-192 was sky condition clear with winds out of the southwest at 15 knots gusting to 25 knots and 7 miles or greater visibility (Tab F-2 and F-

4). Additionally, the forecast illumination for NVG training was high illumination for the first hour after the scheduled takeoff, then transitioning to low illumination at approximately 1930L (Tab F-6).

b. Observed Weather

The observed weather at Holloman AFB at the time of the mishap was sky condition clear with winds out of the south at 6 knots gusting to 15 knots and 10 miles or greater visibility (Tab F-16). The observed weather on IR-192 at the time of the mishap was sky condition clear with winds out of the west-southwest at 15 knots gusting to 25 knots and 7 miles or greater visibility (Tab F-34 to F-36). Additionally, the observed illumination for NVG training was assessed to be high illumination by the aircrew (Tab R-2.6).

c. Space Environment

Not applicable.

d. Operations

No evidence suggests the MP was operating outside prescribed operational limits with respect to weather conditions (Tab F-2).

8. Crew Qualifications

The MP was a current and qualified flight examiner in the F-16 at the time of the mishap (Tab G-4 and G-9). In the F-16, the MP had 1813.1 hours, 553.8 instructor hours, and 7.6 evaluator hours (Tab G-5). The MP obtained his initial mission qualification in the F-16 on 16 September 2008 and his initial instructor pilot qualification on 6 December 2016 (Tab G-18). The MP maintains a current Form 8 instrument and mission qualification dated 7 May 2019 (Tab G-18). Finally, the MP was current and qualified as an instructor in NVGs and was qualified to fly low altitude at night at the time of the mishap (Tabs G-4 and AA-13).

Recent flight time is as follows (Tab G-5):

MP	Hours	Sorties
30 days	11.4	8
60 days	18.9	14
90 days	36.7	26

9. Medical

a. Qualifications

Records show the MP was medically-qualified for flight duties at the time of the mishap (Tab X-3 and X-4). The MP completed the Periodic Health Assessment (PHA) on 14 May 2019 (Tab X-3 and X-4). A comprehensive review of the medical records identified that the MP has an indefinite waiver, approved by Headquarters (HQ) United States Air Forces Europe (USAFE) on 22 March 2017, for two conditions that were assessed not to adversely affect the MP's ability to perform regular flight duties (Tab X-3).

b. Health

After successfully ejecting, the MP spent approximately one and a half hours on the ground and was transferred via US Army UH-60 to a local regional military medical center (a level II trauma center) for evaluation (Tabs R-1.11 and X-3). The medical center's evaluation concluded the MP had suffered minimal injury to extremities (Tabs R-1.18 to R-1.20 and X-3). The MP was discharged for later follow-up at Holloman AFB clinic (Tab R-1.18 to R-1.20). A review of the MP's 72-hour and 7-day history revealed the MP to be in good health and uncovered no evidence of a medical condition impeding the MP's ability to perform flying duties prior to the mishap (Tabs R-1.21 to R-1.32 and X-3). Additionally, review of 72-hour and 7-day histories of the maintenance personnel showed no evidence of medical conditions that would impede their ability to safely perform their duties in the days immediately preceding the mishap. (Tab X-3).

c. Pathology

The Defense Health Agency tested blood and urine samples from the MP for carbon monoxide, ethanol, and intoxicating drugs and tested samples from maintenance personnel for ethanol and intoxicating drugs (Tab X-5). Carbon monoxide saturation levels for the MP tested within normal levels, and the test returned negative results for intoxicating drugs and ethanol (Tab X-5). Test results for maintenance personnel contained no evidence of intoxication prior to the mishap. (Tab X-5).

d. Lifestyle

No lifestyle factors were identified for the MP or aircraft maintenance personnel that are indicative of an inability to safely perform their duties (Tab X-3).

e. Crew Rest and Crew Duty Time

Per AFI 11-202, Volume 3, *General Flight Rules*, dated 10 August 2016, aircrew members require at least 12 non-duty hours before a Flight Duty Period and an opportunity for at least 8 hours of uninterrupted sleep (Tab BB-28). Based on the MP's 72-hour and 7-day history, the MP did not have any scheduled training or duty during the 12 hours prior to arriving at the squadron on the day of the mishap (Tabs R-1.21 to R-1.32 and X-3). Similarly, AFI 21-101, *Aircraft and*

Equipment Maintenance Management, dated 21 May 2015, limits maintenance members to no more than 12 hours of continuous duty in a 24-hour period unless given the opportunity for 8 hours of uninterrupted sleep (Tab BB-26). A review of the 72-hour and 7-day histories for the maintenance crews found no violation of the duty-hour limitations (Tab X-3).

10. OPERATIONS AND SUPERVISION

a. Operations

The 314 FS operations tempo was normal (Tab AA-3). The week the mishap took place was the last of four weeks of night flying for the MP (Tab R-1.5). No evidence indicates that operations tempo or other operational factors impacted the mishap.

b. Supervision

The mission was authorized by the 314 FS operations supervisor, and a review of flight training records showed the MP and other flight members were current and qualified to participate in the scheduled sortie (Tabs G-4, K-4 to K-5 and AA-6 to AA-14). There were minor discrepancies found on the flight authorization, but no evidence indicates that the supervisory practices or supervision contributed to the mishap (Tab K-4 to K-5).

11. HUMAN FACTORS ANALYSIS

a. Introduction

The Department of Defense (DoD) Human Factors Analysis and Classification System Version 7.0 (HFACS), defines potential human factors for assessment during a mishap investigation (Tab BB-17 to BB-18). The DoD HFACS is divided into four main categories: acts, preconditions, supervision, and organizational influences (Tab BB-18). The DoD HFACS identifies sources of data for potential human factors such as witness testimony, medical records, toxicology results, video and audio recordings, and flight reconstructions (Tab BB-17 to BB-22).

b. AE102 Checklist Not Followed Correctly

HFACS code AE102 is a factor when the individual, either through an act of commission or omission, makes a checklist error or fails to use an appropriate checklist (Tab BB-19).

The WCD from the depot maintenance records and analysis of the aircraft wreckage demonstrate the checklist for the installation of the 1st Stage Rear Air Seal was not followed correctly (Tabs U-29 to U-33 and DD-19).

c. AE103 Procedure Not Followed Correctly

HFACS code AE103 is a factor when a procedure is performed incorrectly or accomplished in the wrong sequence (Tab BB-19).

The WCD from the depot maintenance records demonstrate that both the DMTr and DME did not follow proper stamp procedures for accurately verifying the work of the DMTe (Tabs R-2.20, R-3.5, R-4.18, and U-29 to U-33). The DMTe was allowed to accomplish work unsupervised, with the DMTr and DME reviewing work up to a day later (Tabs R-2.20, R-3.5, R-4.18, and U-29 to U-33). Additionally, delaying work review of the DMTe created a situation in which the DMTr and DME were unable to verify the failure of the DMTe to install the 1st Stage Rear Air Seal (Tabs U-30 to U-31, V-3.5, V-3.20, V-3.24, and V-4.19).

d. PC206 Overconfidence

HFACS code PC206 is a factor when the individual overvalues or overestimates personal capability, the capability of others or the capability of the aircraft, vehicles, or equipment (Tab BB-20).

Based on review of the WCD, DMTr and DME demonstrated overconfidence in the DMTe to assemble sections of the IFM without immediate oversight (Tab U-29 to U-33).

e. SV001 Failure to Enforce Existing Rules (Supervisory Act of Omission)

HFACS code SV001 is a factor when operating rules have not been enforced by a supervisor (Tab BB-21).

Based on interviews and review of the WCD, the DMTe, DMTr, and DME allowed work to proceed to subsequent steps for the assembly of the IFM before appropriate supervisory review was accomplished and required documentation stamped (Tabs U-29 to U-33 and V-2.12, V-2.27, V-3.5, V-4.10).

f. SV004 Authorized Unqualified Individuals for Task

HFACS SV004 is a factor when an individual has not met the general training requirements for the job or weapon system and is considered noncurrent, but supervision allows the individual to perform the task (Tab BB-21).

According to WCDs, the DMTe accomplished work on the IFM for the ME on 18 September 2016, while training records indicate the DMTe was authorized to start OJT for these tasks on 17 October 2016 (Tabs G-46 and U-29 to U-33). Consequently, the DMTe accomplished maintenance before OJT was authorized per Oklahoma Air Logistics Complex directives (Tabs G-46, U-29 to U-33, and BB-14). Additionally, based on review of the WCDs and stamp dates, the DMTr allowed the DMTe to accomplish maintenance unsupervised (Tab U-29 to U-33).

g. OP001 Workload

HFACS code OP001 is a factor when the pace of deployments, workload, additional duties, off-duty education, professional military education (PME) or other workload-inducing conditions of an individual or unit creates an unsafe situation (Tab BB-22).

During interviews, the DMTr stated the depot engine work was rushed, especially at the end of the month or around holidays (Tab R-6.19). The reason for this was stated to be the scheduler's requirement to produce a specified number of engine modules per month without taking into account the number of off-days (Tab R-6.19). The DMTr stated this oversight created a necessity for overtime to complete the number of scheduled IFMs (Tab R-6.19).

According to interviews, the high demand for IFMs taxed the supply section and created a situation in which IFM build kits occasionally did not have all parts included when delivered (Tabs R-6.14, V-3.14, and V-4.7). As a result, it is possible the 1st Stage Rear Air Seal was not included in the build kit for the ME's IFM assembly (Tabs R-6.14, V-2.29, V-3.12 to V-3.13, and V-4.15).

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Publically Available Directives and Publications Relevant to the Mishap

1. AFMAN 11-2F-16, Volume 1, F-16 Pilot Training, dated 16 June 2019
2. AFI 11-2F-16, Volume 1, Air Education and Training Command Supplement, F-16-Pilot Training, dated 8 January 2016.
3. AFI 11-2F-16, Volume 3, F-16 Operations Procedures, dated 13 July 2016, Incorporating Change 1, dated 26 May 2017.
4. AFI 11-202, Volume 3, General Flight Rules, dated 10 August 2016.
5. AFI 11-202, Volume 3, Air Education and Training Command Supplement, General Flight Rules, dated 30 January 2017.
6. AFI 11-214, Air Operations Rules and Procedures, dated 14 August 2012, Incorporating Change 1, dated 23 March 2016.
7. AFI 11-214, Air Education and Training Command Supplement, Air Operations Rules and Procedures, dated 15 July 2016.
8. AFI 44-170, Preventive Health Assessment, dated 30 January 2014.
9. AFI 48-123, Medical Examinations and Standards, dated 5 November 2013.
10. AFI 51-307, Aerospace and Ground Accident Investigations, dated 18 April 2019.
11. AFSCM 21-102, Depot Maintenance Management, dated 11 March 2019
12. AFSCM 21-102, Oklahoma City Air Logistics Complex Supplement, Depot Maintenance Management, dated 19 September 2018

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. DoD Human Factors Analysis and Classification System (HFACS) Version 7.0, dated 27 April 2018.
2. Air Force Tactics, Techniques and Procedures 3-3.F.F-16, Combat Aircraft Fundamentals F-16, dated 6 October 2017
3. F-16 Pilot Training Course Lesson Guide, SFO Procedures -L-183, dated 17 July 2015.
4. F-16 Pilot Training Course Lesson Guide, ECS Introduction Subsystems and Emergency Procedures-L-160, dated 25 September 2017.
5. Medical Standards Directory, 10 September 2019.
6. Air Force Technical Order (TO) 00-20-1, Aerospace Equipment Maintenance Inspection, Documentation, Policies and Procedures, dated 1 April 2016.

7. TO 1F-16CG-2-00GV-00-1 General Vehicle Organizational Maintenance Description, dated 1 December 2019.
8. TO 1F-16CG-6WC-1, Combined Preflight/Post-flight, End-of-Runway, Thru-flight, Launch and Recovery, Alert Inspections, Quick Turnaround, Basic Post-flight and Walk around Before First Flight of Day Inspection work cards, dated 1 November 2013.
9. TO 1F-16CM-1, Flight Manual USAF Series F-16C and F-16D CCIP Blocks 40, 42,50, and 52 Aircraft, dated 1 May 2019.
10. TO 1F-16CM-1-1, Supplemental Flight Manual USAF Series F-16C and F-16D CCIP Blocks 40, 42,50, and 52 Aircraft, dated 1 May 2019
11. United States Air Force School of Aerospace Medicine Waiver Guide, dated 12 December 2019.

DEBOER.JOEL.R.1185951479 Digitally signed by DEBOER.JOEL.R.1185951479 Date: 2020.04.12 17:17:34 -06'00'

10 April 2020

JOEL R. DEBOER, Colonel, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

F-16, T/N 90-0755
Holloman Air Force Base, New Mexico
29 October 2019

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 by the United States or by any person referred to in those conclusions or statements.

1. OPINION SUMMARY

On the night of 29 October 2019 at 1906L, an F-16C Block 42 aircraft tail number (T/N) 90-0755 crashed approximately 95 miles southeast of Holloman Air Force Base (AFB), New Mexico (NM). This aircraft was operated out of Holloman AFB, NM by the 314th Fighter Squadron (FS), 54th Fighter Group (FG), assigned to the 49th Wing. The pilot was able to safely eject, but the aircraft was completely destroyed on impact.

The Mishap Aircraft (MA) departed Holloman AFB at 1826L for a routine mission as part of a three-ship night instructor continuation training (CT) sortie to maintain night vision goggle (NVG) and low-altitude navigation currencies on a local low-level instrument route (IR) flying over southern NM and western Texas. At 1906L, approximately 40 minutes after takeoff, the MA, while flying the number three position in a trail formation, experienced catastrophic engine failure resulting in an uncontrollable engine fire at low altitude, leading to the Mishap Pilot's (MP) decision to abandon the aircraft. The MP ejected safely and was recovered by a United States Army helicopter from Fort Bliss, Texas.

2. CAUSE

I find by a preponderance of the evidence, the cause of the mishap was the failure to install the 1st Stage Rear Air Seal onto the 2nd Stage Fan Disk in the Inlet Fan Module (IFM) during depot-level maintenance in September 2016. Due to the absence of the 1st Stage Rear Air Seal, the 2nd Stage Fan Blades eventually migrated forward approximately .4 to 1.0 inches until eventually, after 591 hours of engine operation and under tensile and shear overstresses, both the fan blades and pieces of the lugs for the compressor disk holding the fan blades in place broke free, resulting in catastrophic failure of the engine and causing a significant loss of thrust. Additionally, the engine failure led to an uncontained fire after an unknown number of compressor blades penetrated through the engine bay heat shield, piercing the A-1 fuel tank. The subsequent fire, fed by fuel from the perforated A-1 fuel tank, grew uncontrolled leading to numerous failures within the flight control and hydraulic systems located near the engine.

Post-mishap engine analysis clearly validates the absence of the 1st Stage Rear Air Seal. There was no evidence of the 1st Stage Rear Air Seal found at the crash site (portions of all other air seals were found). There were no apparent witness marks on the 2nd Stage Fan Hub radial interface that mates with the 1st Stage Rear Air Seal. The dry lubricant on the mounting holes was undisturbed and had no apparent witness marks on the 2nd Stage Fan Disk Forward Balance Flange from pins and collars that would have been installed during assembly or been forcefully removed during ground impact. Finally, there were no apparent witness marks on the forward face of the 2nd Stage Fan Disk Blade Root Platform from contact with the 1st Stage Rear Air Seal. It is my opinion, along with all the engine experts analyzing the wreckage, the 1st Stage Rear Air Seal was not installed during depot-level maintenance.

Additionally, I lend no credibility to the depot maintenance work control documents (WCD) for the installation of the 1st Stage Rear Air Seal due to the annotation of the 2nd Stage Rear Air Seal part and serial numbers where the 1st Stage Rear Air Seal part and serial numbers were to be recorded. Finally, the disparity in dates from installation to verification indicate that the 1st Stage Rear Air Seal installation was never visually verified.

3. SUBSTANTIALLY CONTRIBUTING FACTORS

I find by a preponderance of evidence that each of the following factors substantially contributed to the mishap: unqualified/untrained maintenance personnel, lack of supervision, and negligent procedural practices.

a. Unqualified/Untrained Maintenance Personnel

On 18 September 2016, the WCDs, which are the official record for work including control, identification, inspection, and routing of operations, indicate that the Depot Maintenance Trainee (DMTe) built the 2nd and 3rd Stage Compressors and Rotor Assemblies by placing the blades onto the compressor hub and also began to assemble, or "stack", the rotors and stators for the 1st and 2nd Stages of the IFM. According to section 21.3.14.3.2.1 of Air Force Sustainment Center Manual 21-102_OC-ALCSUP, *Depot Maintenance Management*, "Any mechanic/technician in a training status for a PAC [Production Acceptance Certification] task shall have a PAC task assigned and an OJT [on-the-job training] start date entered." Upon review of the DMTe's training records, the OJT start date annotated was 17 October 2016, indicating the DMTe should not have accomplished any of the tasks performed on 18 September 2016.

As a result of being unqualified and untrained in the tasks, the DMTe did not adhere to technical orders (TO) and procedures during the assembly of the 2nd Stage Compressor and Rotor Assembly and failed to install the 1st Stage Rear Air Seal. According to section 7.4.2 and 7.2.12.4.1 of Air Force Sustainment Center Manual 21-102, *Depot Maintenance Management*, maintenance stamps are mandatory and "will be issued to maintenance personnel to certify, by stamping and dating, the work has been accomplished and completed as required by specified technical data." The WCD requires the installation of the 1st Stage Rear Air Seal onto the 2nd Stage Fan Disk and the annotation of the seal's serial number. Under this step, the DMTe incorrectly annotated the 2nd Stage Air Seal's serial number in place of the 1st Stage Rear Air Seal and stamped the WCD step complete. It is physically impossible to install the 2nd Stage Rear Air Seal in the location of the 1st Stage Rear Air Seal. It is my opinion that the failure to install the 1st Stage Rear Air Seal was a result of the DMTe being insufficiently trained and supervised in the task and likely due to a missing 1st Stage Rear Air Seal from the module's build kit.

b. Lack of Supervision

On Sunday, 18 September 2016, Depot Maintenance Employee (DME), Depot Maintenance Trainer (DMTr), and DMTe were working overtime in order to complete IFMs along with two other individuals. According to the WCD, the DMTe built the 2nd and 3rd Stage Compressor and Rotor Assemblies and assembled the rotors and stator cases for the 1st and 2nd Stages of the IFM. Although both the DMTr and the DME were present, neither signed off each step of DMTe's work as required. It wasn't until Monday, 19 September 2016, that DMTr and DME signed off the DMTe's work. Unfortunately, based on the WCDs and the point to which the DMTe worked ahead, the missing 1st Stage Rear Air Seal was not visible to either the DMTr or DME as the 2nd Stage Stator Case around the 2nd Stage Fan Disk and Blades prevented viewing of the 1st Stage Rear Air Seal. In my opinion, the DMTr was not applying the appropriate level of supervision for the training of the DMTe, which subsequently led to the DMTr missing the installation of the 1st Stage Rear Air Seal on the 2nd Stage Fan Disk. Additionally, it is my opinion that the DME, as the certified inspector, did not verify the installation of the 1st Stage Rear Air Seal as required in the WCD.

c. Negligent Procedural Practices

According to procedure, maintenance personnel are not to move to the next step until the previous steps have been verified and signed off. On 18 September 2016, the DMTe marked completion of steps without the DMTr verifying the step was completed correctly. Additionally, the DMTr, as the trainer, failed to verify the DMTe completed each step correctly. Instead, the DMTr signed off on the tasks a day later on 19 September 2016.

According to section 7.4.6.3 of Air Force Sustainment Center Manual 21-102_OC-ALCSUP, *Depot Maintenance Management*, some crucial steps require an additional or secondary buy-off, which is designed for steps that are more critical in nature. The WCD demonstrates the secondary buy-offs were not stamped and dated by the DME until a day later on 19 September 2016. It is important to note, on 19 September 2016, when the DMTr and DME stamped and dated the steps, the 2nd Stage Fan Disk and Blades were encased in the 2nd Stage Stator Case, which precluded the inspection of the 1st Stage Rear Air Seal, one of the items the DME was supposed to inspect. It is my opinion the DMTr allowed the DMTe to accomplish unsupervised work for which he was not qualified, while "verifying" the work accomplished at a later date. Additionally, it is my opinion both the DMTr and DME negligently signed off work without actually verifying the steps were accomplished.

4. CONCLUSION

I find, by a preponderance of the evidence, the cause of the mishap was the catastrophic failure of the engine resulting from the failure to install the 1st Stage Rear Air Seal during the overhaul of the IFM by depot-level maintenance personnel at Tinker AFB, Oklahoma in September 2016. Without the 1st Stage Rear Air Seal, the 2nd Stage Fan Blades eventually migrated forward until the excessive strain of operation resulted in the liberation of 2nd Stage Fan Blades, leading to a significant loss of thrust and uncontained engine fire fueled by a perforated A-1 fuel tank. Additionally, I find by a preponderance of the evidence, the failure to install the 1st Stage Rear Air Seal during depot maintenance was a result of the following substantially contributing factors: unqualified and untrained maintenance personnel, lack of supervision, and negligent procedural practices. The failure to install the 1st Stage Rear Air Seal resulted from a failure to follow checklist procedures by an unqualified and untrained trainee who was not under the immediate supervision of a trainer. The failure was compounded by the trainee continuing assembly to a point where proper installation could no longer be verified, yet both the DMTr and DME stamped completion anyway. Therefore, I find the DMTe, DMTr, and DME were all causal to the mishap.

DEBOER.JOEL.R.1185951479 Digitally signed by DEBOER.JOEL.R.1185951479 Date: 2020.04.12 17:17:50 -06'00'

10 April 2020

JOEL R. DEBOER, Colonel, USAF
Accident Investigation Board President

INDEX OF TABS