UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION
BOARD REPORT

F-16C, T/N 87-0358

8TH FIGHTER SQUADRON
49TH WING
HOLLOMAN AIR FORCE BASE

LOCATION: HOLLOMAN AIR FORCE BASE, NEW MEXICO

DATE OF ACCIDENT: 30 APRIL 2024

BOARD PRESIDENT: COLONEL JAMES B. STEWART

Conducted IAW Air Force Instruction 51-307

ACTION OF THE CONVENING AUTHORITY JAN 2 9 2025

The report of the accident investigation board, conducted under the provisions of AFI 51-307, *Aerospace and Ground Accident Investigations,* that investigated the 30 April 2024 mishap, near Holloman Air Force Base, New Mexico, involving an F-16C, aircraft, T/N 87-0358, assigned to the 8th Fighter Squadron, Holloman Air Force Base, New Mexico, substantially complies with applicable regulatory and statutory guidance and on that basis is approved.

BRIAN S. ROBINSON
Lieutenant General, USAF
Commander, Air Education & Training Command

EXECUTIVE SUMMARY
UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION

F-16C, T/N 87-0358
HOLLOMAN AIR FORCE BASE, NEW MEXICO
30 APRIL 2024

On 30 April 2024, at approximately 1144 local time, an F-16C with tail number (T/N) 87-0358 assigned to the 49th Wing, Holloman Air Force Base (AFB), New Mexico, crashed six and a half nautical miles southwest of the departure end of Holloman AFB Runway 25. The flight was planned and authorized as a Basic Surface Attack training mission within the local airspace. The weather was clear skies with unrestricted visibility and light winds out of the west. Thirty-six seconds after take-off, the mishap aircraft (MA) experienced an engine loss of thrust while at 1,030 feet above ground level. The mishap pilot (MP) initiated corrective action procedures, and due to the low altitude and decreasing airspeed, the MP ejected one minute and eighteen seconds after the engine loss of thrust. Shortly after the MP's ejection, the MA was destroyed upon impact within White Sands National Park, with a total loss valued at $21,702,152. The MP sustained only minor injuries from the ejection and was recovered by an Army Air helicopter within minutes.

There were no relevant aircrew discrepancies or maintenance write-ups on the MA when flown the day prior and the day of the accident. Normal prelaunch and launch procedures occurred on the day of the mishap. Local maintenance actions leading up to the mishap were conducted following applicable guidance, however local maintainers cannot access or inspect the fifth stage of the engine. The pilot was current, qualified, medically fit, and performed appropriate actions. The scheduled mission was supervised correctly and released by pertinent authorities.

The Board President found, by a preponderance of the evidence, that the cause of the mishap was a misaligned, or turned, number ten position variable stator vane in the fifth stage of the MA engine. Over time, the airflow disturbance from passing through the turned fifth stage vane caused high cycle fatigue of a fifth stage compressor blade. The blade eventually separated during flight, causing additional engine damage and significant airflow disruption, resulting in an engine loss of thrust. There was insufficient evidence to determine the cause of the turned vane.

SUMMARY OF FACTS AND STATEMENT OF OPINION
F16C, T/N 87-0358
HOLLOMAN AFB, NEW MEXICO
30 APRIL 2024

TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS

AB	Afterburner
ACES	Advanced Concept Ejection Seat
AETC	Air Education & Training Command
AFB	Air Force Base
AFI	Air Force Instruction
AFLCMC	Air Force Life Cycle Management Center
AFMAN	Air Force Manual
AFPET	Air Force Petroleum Lab
AGL	Above Ground Level
AIB	Accident Investigation Board
AMXS	Aircraft Maintenance Squadron
BPO	Basic Post-flight
BSA	Basic Surface Attack
Capt	Captain
CCY	Calculated Cycles
CSFDR	Crash Survivable Flight Data Recorder
CSMU	Crash Survivable Memory Unit
CO	Convening Order
DFLCC	Digital Flight Control Computer
DOD	Domestic Object Damage
DoD	Department of Defense
EPU	Emergency Power Unit
FDP	Flight Duty Period
FDT	Fan Drive Turbine
FG	Fighter Group
FOD	Foreign Object Damage
FS	Fighter Squadron
ft	Feet
FTU	Formal Training Unit
HCF	High Cycle Fatigue
HP	Helicopter Pilot
HPC	High-Pressure Compressor
HPT	High-Pressure Turbine
IAW	In Accordance With
IFT	In Flight Time
IFM	Inlet Fan Module
in	Inches
IP	Instructor Pilot
JOAP	Joint Oil Analysis Program
KCAS	Knots Calibrated Airspeed
KIO	“Knock it off”
L	Local Time
lbs	Pounds
LM	Lockheed Martin
LPT	Low-Pressure Turbine
MA	Mishap Aircraft
Maj	Major
Mil	Military
MP	Mishap Pilot
MXS	Maintenance Squadron
NM	New Mexico
NOTAM	Notices of Airmen
OK	Oklahoma
P1A	Position One Alpha pilot (front seat)
P1B	Position One Bravo pilot (back seat)
P2	Position two pilot
P3	Position three pilot
P4	Position four pilot
P&W (PW)	Pratt & Whitney
PR	Pre Flight
RPM	Revolutions Per Minute
SFS	Security Forces Squadron
TCTO	Time Compliance Technical Orders
T/N	Tail Number
TSgt	Technical Sergeant
W	Witness
WG	Wing
Z	Zulu Time

SUMMARY OF FACTS

1. AUTHORITY AND PURPOSE

a. Authority

On 15 May 2024, Lieutenant General Brian S. Robinson, Commander, Air Education and Training Command (AETC), appointed Colonel James B. Stewart as board president of this Accident Investigation Board (AIB) to conduct an accident investigation of the 30 April 2024 crash of a F-16C, T/N) 87-0358. (Tab Y-2 to Y-3). The Mishap Aircraft (MA) was assigned to the 49th Wing (49 WG), Holloman Air Force Base (AFB), New Mexico (NM). (Tab K-2). The investigation was conducted under the provisions of Air Force Instruction (AFI) 51-307, *Aerospace and Ground Accident Investigations*, dated 18 May 2019 (administrative change 6 April 2023). (Tab Y-1). Other members detailed to this AIB included: Major (Maj) Legal Advisor; Maj Medical Member; Captain (Capt) Pilot Member; and Technical Sergeant (TSgt) Maintenance Member. (Tab Y-1). On 6 June 2024, the needs of the Air Force required an amendment to the AIB Convening Order (CO). Changes to the CO included: replacing the Capt pilot member with a Maj pilot member; replacing the Maj medical member with a Lieutenant Colonel medical member; and a TSgt Recorder was appointed. (Tab Y-3). This investigation was conducted at Holloman AFB, NM from 18 July to 4 August 2024, with an in-person visit to Tinker AFB, Oklahoma on 8 August 2024.

b. Purpose

In accordance with (IAW) AFI 51-307, 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 30 April 2024, at 1144 approximately local time (L), the MA, an F-16C, T/N 87-0358, crashed six and a half nautical miles southwest of the departure end of Runway 25, Holloman AFB. (Tabs Z-3 and Z-11). Both the Mishap Pilot (MP) and the MA were assigned to the 8th Fighter Squadron (8 FS), 49th Wing (49 WG), Holloman AFB, NM. (Tab G-4). The flight was planned and authorized as a Basic Surface Attack (BSA) training mission within the local airspace. (Tabs K-4 and BB-33). The weather was clear skies with unrestricted visibility and light winds from the west. (Tab F-2). Thirty-six seconds after take-off, the MA experienced an engine loss of thrust while at 1,030 feet (ft) above ground level (AGL). (Tabs J-12 and Z-6). The MP initiated corrective actions, but due to the low altitude and decreasing airspeed, the MP ejected one minute and eighteen seconds after the engine loss of thrust. (Tabs V-1.8, Z-7 to Z-10, BB-2 to BB-5, BB-7, and DD-1). The MA was destroyed upon impact within White Sands National Park, NM, with a total loss valued at $21,702,152. (Tabs P-1 and Z-11). The MP sustained only minor injuries and, was recovered by an Army Air helicopter within several minutes of his parachute descent before being taken to a local hospital. (Tabs N-12 to N-14, V-2.8, V-2.12, V-6.6, V-7.2, V-1.10 to V-1.12, DD-4).

3. BACKGROUND

a. Air Education and Training Command

Headquartered at Joint Base San Antonio – Randolph, Texas, AETC, was established and activated in January 1942, making it the oldest major command in the Air Force. (Tab CC-1). AETC's primary mission is to recruit, train, and educate exceptional Airmen to deliver 21st Century Airpower. (Tab CC-1). AETC includes Air Force Recruiting Service, two numbered air forces, and Air University. (Tab CC-1). The command operates 12 major installations and supports tenant units on numerous bases across the globe. (Tab CC-1). There are also 16 active-duty and 7 Reserve wings. (Tab CC-1). Over 29,000 Active-Duty members, 6,000 Air National Guard and Air Force Reserve personnel, and 15,000 civilian personnel serve in AETC. (Tab CC-1). The command also has more than 11,000 contractors assigned. (Tab CC-1). AETC flies approximately 1,300 various aircraft. (Tab CC-1).

b. 49th Wing

Located at Holloman AFB, NM, the 49 WG supports national security objectives by deploying worldwide to support peacetime and wartime contingencies. (Tab CC-1). The wing provides combat-ready Airmen and Guardians and trains F-16 Fighting Falcon pilots and MQ-9 Reaper aircrew. (Tab CC-1). Additionally, the wing delivers Air Transportable Clinics and Basic Expeditionary Airfield Resources while supporting more than 21,000 military and civilian personnel. (Tab CC-1). The wing has a proud history of service in World War II, Korea, Southeast Asia, Southwest Asia, and NATO-led Operation Allied Force. (Tab CC-1).

c. 54th Fighter Group

The 54th Fighter Group (54 FG) at Holloman AFB, NM, trains an average of 180 students through more than 10,800 sorties and 14,600 hours per year. (Tab CC-1). The 54 FG is comprised of five squadrons, including the 311 FS, 314 FS, 8 FS, 54th Training Squadron, and 54th Operations Support Squadron. (Tab CC-1). The group is comprised of 800 personnel, maintaining $2.2 billion in F-16 assets, and executes a $144 million operations and maintenance budget to conduct F-16 training. (Tab CC-1).

d. 8th Fighter Squadron

The 8 FS flies the F-16 Fighting Falcon. (Tab CC-1). The squadron's primary mission is to generate new F-16 fighter pilots and requalify former F-16 fighter pilots. (Tab CC-1). Producing fighter pilots who are first and foremost Airmen professionals, the 8 FS is passionate about their lethal craft. (Tab CC-1).

e. F-16 Fighting Falcon

The F-16C Fighting Falcon is a single-engine, compact, multi-role fighter aircraft. (Tab CC-1). It is highly maneuverable and has proven itself in air-to-air combat and air-to-surface attacks. (Tab CC-1). The F-16C provides a relatively low-cost, high-performance weapon system for the United States and allied nations. (Tab CC-1). In an air combat role, the F-16's maneuverability and combat radius (*i.e.* the distance it can fly to enter air combat, stay, fight, and return) exceeds all potential threat fighter aircraft. (Tab CC-1). The F-16C can locate targets in all weather conditions and detect low-flying aircraft in radar ground clutter. (Tab CC-1). In an air-to-surface role, the F-16 can fly more than 500 miles (*i.e.* 860 kilometers), deliver its weapons with superior accuracy, defend against enemy aircraft, and return to its starting point. (Tab CC-1). An all-weather capability allows accurate ordnance delivery during non-visual bombing conditions (Tab CC-1).

f. Pratt & Whitney F100-PW-220 Engine

The high-performance Pratt & Whitney F100 turbofan engine is the power plant for most F-16 Fighting Falcons. (Tab CC-1). Development of the F100 series began in the late 1960s, and the F100-PW-220 version is still used today in F-15s and many F-16s. (Tab CC-1). Early F100 engines were at the cutting edge of jet engine technology despite initially experienced early developmental challenges. (Tab CC-1). However, continued improvements made the F100 series durable, reliable, and more powerful. Since its debut, F100 engines have surpassed 30 million flight hours – nearly three times as many hours as other fourth-generation fighter engines. (Tab CC-1). The F100 series remains in use within the air forces of twenty-three countries and continues to be an important military power plant far into the twenty-first century. (Tab CC-1). For the United States Air Force, the F100 engine currently meets its aggressive mean time between removal requirement, which increased in 2020 because of its consistent performance. (Tab CC-1).

Technical Notes: The F100-PW-220 engine has a low bypass ratio and high compression ratio, and it is a twin-spool turbofan engine with a mixed flow augmentor. (Tab J-45). 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 J-45). The HPC and HPT are shipped together, often called "the Core." (Tab J-45). The engine has a maximum thrust (with afterburner (AB)) of 23,770 pounds (lbs), a weight of 3,234 lbs, a length (with AB) of 15 ft 11 inches (in), and a diameter of 3 ft 10.5 in. (Tab CC-1).

4. SEQUENCE OF EVENTS

a. Mission

The MP was part of a four-ship formation of two single-seat model F-16Cs and two dual-seat model F-16Ds. (Tabs K-1, V-2.6, V-2.12, and AA-2). The formation was set to conduct an F-16

Formal Training Unit (FTU) syllabus-prescribed BSA training mission within the local airspace. (Tabs K-1, V-2.6, V-2.12, and BB-33).

b. Planning

Standard procedures were used for the formation's mission planning. (Tabs V-1.2, V-3.5, and V-5.8). The formation flight lead in the number one position (P1A) was an FTU Instructor Pilot (IP). (Tab G-20). P1A was also the IP and element lead for a student pilot going through the basic qualification course in the number two position (P2). (Tab G-20). The MP was in the number three position (P3) and was the FTU IP for the number four position student pilot (P4), who was also going through the basic course (Tab G-20). An additional pilot (P1B) observed the day's mission from the rear seat of P1A's aircraft. (Tab G-20).

Prior to the flight, the MP and other pilots in formation attended a mass briefing given by the Operations Supervisor, also known as "Top 3," which consisted of weather, Notices to Airmen (NOTAMS), aircraft configurations, and other pertinent data. (Tab V-5.4). After the mass briefing, P1A prepared and accomplished the formation's flight briefing. (Tab V-1.2 and V-3.15). This briefing covered all necessary sortie events and required briefing topics, including flight administration, emergency procedures, search and rescue procedures, and the events and tactical plans for the BSA training mission. (Tabs V-2.6, V-2.12, V-3.9, and V-3.15). All formation members accomplished and discussed a standard operational risk management assessment. (Tabs V-2.3 and AA-1).

c. Preflight

The planned "step" briefing from the "Top 3" immediately before leaving for the aircraft was to be at 0955L but was changed to 1030L due to airspace constraints and time deconfliction with another four-ship formation already airborne. (Tabs G-20 and V-2.6 to 2.7). At step time, all formation pilots received an update on the airfield's status, weather, NOTAMs, flight plan, and aircraft assignments before departing to their aircraft. (Tab V-5.4).

As briefed, the MA was in a "B00" configuration, which includes a single 300-gallon external centerline fuel tank (Tabs J-6, K-1, and K-4). Routine pre-launch and launch procedures were conducted by the launching crew chief. (Tabs V-8.2 to V-8.3). While holding short at the end of the runway before take-off, P1A directed the formation set communications radio one to preset channel one (8 FS "Ops" on Ultra High Frequency or UHF) and preset channel three ("Tower" on Very High Frequency or VHF) in communications radio two due to interference on the originally planned frequencies. (Tabs N-3 to N-4, N-8, V-1.5, V-1.8, V-2.3, V-2.7, V-2.12, V-4.3, and BB-31 to BB-32). Neither the 35-minute delay nor the adjusted communications setup detracted from the formation's preflight tasks, engine start, taxi, takeoff, or the initiation of the local visual flight rules departure routing known as the "MEZR1." (Tabs K-2 to K-4, V-1.6, V-2.6, V-3.9, and BB-29).

d. Summary of Accident

The MA takeoff time was 1142:36L. (Tabs J-5 and K-1). Each aircraft in the formation performed a maximum AB takeoff with fifteen seconds of spacing between formation positions. (Tabs K-1, V-1.6, V-3.3, and Z-4 to Z-5). Following standard procedures, the MP came out of AB just before 300 knots calibrated airspeed (KCAS) and continued accelerating during his departure in military

(Mil) power, or full engine output without AB augmentation. (Tabs V-1.7, Z-5, Z-6, and DD-1). The MP said he then heard a loud bang and felt a loss of thrust, violent shaking, and engine vibrations, so he immediately rolled out of his left, slightly climbing, turning to maintain aircraft control and analyze the situation. (Figures 1 and 2) (Tabs V-1.6 to V-1.8, Z-6, and BB-2 to BB-5).

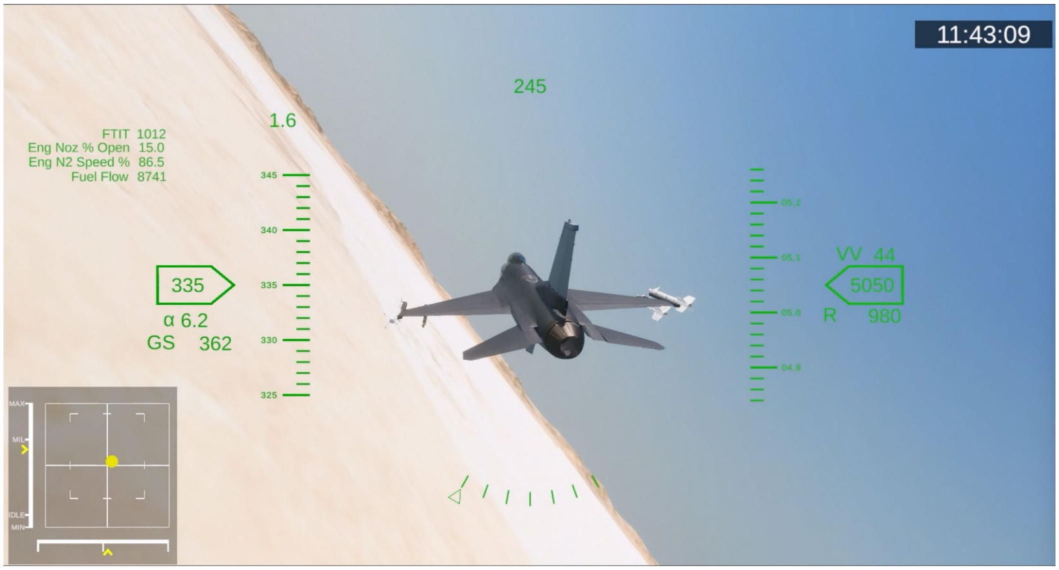

Figure 1. Recorded flight data animation frame capture at "bang" (Tab Z-6)

When the MP heard the bang, felt the shaking, and began his roll-out, the MA was at 1,030 ft AGL with 329 KCAS about one nautical mile from the departure end of Runway 25 on a magnetic heading of 247 degrees. (Tabs V-1.6, V-1.8, Z-1, and Z-6). Recorded engine data showed subsequent rapidly decreasing engine revolutions per minute (RPMs) and a failure of the engine to respond to throttle movement. (Tabs V-1.8 and Z-7 to Z-10).

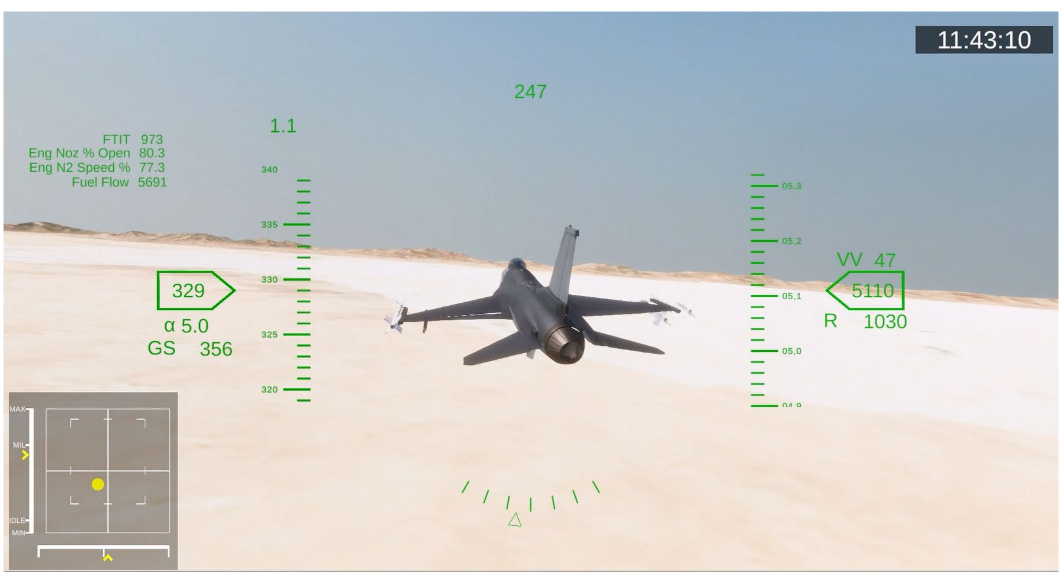

Figure 2. Recorded flight data animation frame capture right after "bang" (Tab Z-6)

A civilian witness below in White Sands National Park (W1) said it looked like a fire burst came out of the back of the MA. (Tab N-1). P4 and an airborne Army Air helicopter pilot (HP) both said they saw a strange, non-standard, orangish color coming from the back of the MA. (Tabs V-3.5, V-6.2, and Z-1). The MP, P4, and HP testimonies, as well as W1's statement, are consistent with the description of an engine loss of thrust from an engine stall or an engine stagnation given in the F-16 flight manual. (Tabs V-1.6, V-1.8, V-3.5, V-6.2, Z-6 to Z-7, and DD-1). The recovered Crash Survivable Memory Unit (CSMU) data also registered an engine stall at 1143:09L, followed by engine stagnation at 1143:10L. (Tabs Z-6 to Z-7).

Engine RPMs decayed below sixty percent within five seconds of the engine loss of thrust. (Z-7). Once RPMs are below 60 percent, the engine is fully stagnated, and any attempted restarts are accomplished through a more time-demanding checklist procedure. (Tab DD-1). Given the MA's altitude of less than 2,000 ft AGL, the loud bang and heavy vibrations indicating engine damage, and RPMs already less than 60%, the flight manual directs prioritizing pre-ejection preparation over attempting a restart. (Tabs V-1.8, BB-2 to BB-5, BB-7, and DD-1). In a loss of thrust at low altitude, the pilot should trade available airspeed for additional altitude. (Tabs H-35, H-39, H-43, BB-2 to BB-5, and DD-1). If the aircraft is not in a position to land on a suitable runway, an ejection should be made, if possible, above 2,000 ft AGL to increase the chances of success. (Tabs H-35, H-39, H-43, BB-2 to BB-5, BB-7, and DD-1).

Using a term generally associated with directing aircrew to stop engagements, scenarios, and tactical maneuvering when the safety of flight is a factor, the MP made a "knock-it-off" (KIO) call on communication radio one at 1143:25L. (Tabs N-8, V-1.8, V-2.7, and DD-1). At the time of the MP's KIO radio call, the MA was at 1,480 ft AGL with 324 KCAS. (Tabs L-1 to L-2 and Z-8). After the MP's KIO call, P4 began flying in an extended chase position to follow the MA instead of continuing the departure. (Tabs N-8 and V-3.4). At 1143:40L, the MP stated over the communication one radio, "engine failure," with an immediate acknowledgment by P1A. (Tabs N-8 and V-2.7). P4 stated, "he punched his tanks," conveying the MP jettisoned his external fuel tank. (Tabs N-8, V-3.10, Z-2, Z-8, and BB-2 to BB-5). P1A began returning towards MP and P4 to assume the primary chase aircraft responsibility and provide mutual support. (Tabs N-8, V-2.8, and Z-3). This was conveyed to and acknowledged by the control tower. (Tabs N-8 and V-2.7). At 1144:21L, the MP stated on the communication one radio, "Three's gonna punch," indicating he was preparing for ejection. (Tabs N-8, V-3.4, BB-2 to BB-5, BB-7, and DD-1). Four seconds later, the MP ejected from the MA at 1,460 ft AGL and 156 KCAS as P4 observed the MP's parachute deployment and reported "good chute". (Tabs L-1 to L-2, N-8, and Z-10).

P1A directed P2 to follow him and sent P4 to orbit over Holloman AFB at a higher altitude. (Tabs N-9 and V-2.8). Air Traffic Control approved altitudes over Holloman AFB and provided a communications relay between P1A and an airborne two-ship formation of Army Air helicopters. (Tabs N-9, V-2.8, and V-6.6). Within five and a half minutes of the ejection, a helicopter with a flight surgeon landed next to the MP. (Tabs N-14, V-1.12, and V-7.2). The MP walked to the helicopter, climbed in, was flown back to Holloman AFB, and then taken by ambulance to the local hospital for a precautionary evaluation. (Tabs N-14, V-1.12, and V-7.2).

e. Impact

According to the Crash Survivable Flight Data Recorder (CSFDR), the last parameters collected by the MA were 156 KCAS at 5,120 ft Mean Sea Level and a true heading of 228 degrees. (Tabs

L-1 to L-2). Within a minute, the MA crashed in White Sands National Park six and a half nautical miles southwest of the departure end of Holloman AFB's Runway 25. (Figures 3 and 4) (Tabs J-7, L-1 to L-2, N-9, N-14, and Z-11). The MA impacted a dune nose first and relatively level. (Tab S-1). A debris field spanned a large fan-shaped area with aircraft pieces scattered over 500 ft away. (Tabs J-6 and Z-12 to Z-23). There was a localized post-impact fire at the impact site. (Tabs N-5, N-9 to N-11, N-17, S-2, V1.10, and V-6.3). The seat, canopy, and centerline fuel tank were scattered to the northeast. (Tab J-7).

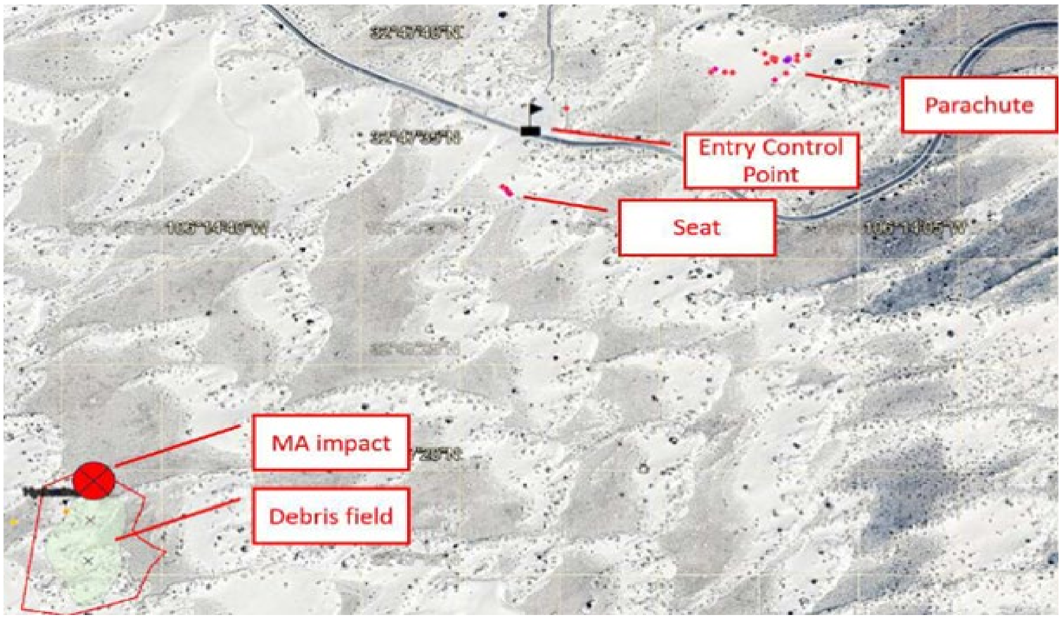

Figure 3. White Sands National Park impact and debris area (Tabs J-7 and Z-12 to Z-23)

Figure 4. Engine and right-hand aft strake, horizontal tail, and speed brake (Tab S-1)

f. Egress and Aircrew Flight Equipment

At 1144:25L, the MP pulled the ejection seat handle located on the forward part of the seat, which began the ejection sequence, canopy separation, and the seat leaving the aircraft milliseconds later. (Tabs H-34, J-12, L-1 to L-2, and N-3). Due to the low altitude and slower airspeed, the advanced concept ejection seat (ACES II) automatically used Mode 1 operation for seat sequencing. (Tabs

H-35, H-39, and H-43). In Mode 1, the main parachute deploys immediately to compensate for the reduced time available for parachute deployment and inflation. (Tabs H-35 and H-39). The emergency escape system functioned sufficiently. (Tabs H-43, V-1.10 to V-1.11, and V-7.2).

The AN/URT-46 distress radio beacon (sometimes referred to as an Emergency Locator Transmitter) never transmitted; however, given the time of day, location of the impact site, and the MP sustaining only minor injuries, the lack of beacon transmissions did not affect the search and rescue operations. (Tabs H-19, H-23, H-33, N-9 to N-10, N-12 to N-13 to N-15, V-2.7 to V-2.8, V-4.9, V-7.7, and BB-30).

g. Search and Rescue

Thirty-five seconds after the ejection, P1A radioed the control tower, stating, "my number three had to eject off the end of the runway." (Tab N-9). Within a minute, all three remaining formation aircraft were over the parachute and impact site while maintaining altitude deconfliction. (Tabs N-9, V-2.7, and BB-30). Two minutes later, P1A established radio communications with the two Army Air helicopters and conveyed the MP's location. (Tabs N-10, V-2.8, and BB-30). At 1150:46L, P1A reported the helicopter landed near the MP's location. (Tabs N-12 and V-2.8). The flight surgeon exited the helicopter and briefly assessed the MP's condition. (Tabs N-14 and V-7.7). The flight surgeon and MP walked to the helicopter, entered, and departed for Holloman AFB. (Tabs N-14 and V-7.7).

During this time, the supervisor of flying in the Holloman AFB control tower started crash response procedures and coordinated with 49th Security Forces Squadron (SFS). (Tabs N-15 and V-4.9). Within twenty minutes of the ejection, 49 SFS arrived at the impact site and the MP's helicopter pick-up location to help protect the integrity of the crash site. (Tabs N-17 and V-2.8). The proximity of the impact site and MP's location, the early notification to tower controllers, and the aid from Army Air all enabled a rapid response. (Tabs N-15 and V-4.9).

h. Recovery of Remains

Not applicable.

5. MAINTENANCE

a. Forms Documentation

The Air Force Technical Order (AFTO) 781 series of forms collectively document all maintenance actions, inspections, servicing, configurations, status, and flight activities. (Tabs BB-22 and DD-2). The AFTO 781 forms, in conjunction with the Integrated Maintenance Data System (IMDS), provide a comprehensive database used to track and record maintenance actions, document flight activity, and schedule future maintenance. (Tabs BB-23 and DD-2). An exhaustive review of the active AFTO 781 forms and IMDS revealed no discrepancies, overdue inspections, or overdue Time Compliance Technical Orders (TCTOs) that would exclude the MA from flying. (Tabs D-1 to D-22 and DD-2 to DD-3).

b. Inspections

Pre-flight (PR) and basic post-flight (BPO) inspections include a visual examination of the aircraft as well as an operational check of specific systems and components to ensure no significant defects or malfunctions exist. (Tabs BB-19 to BB-20 and DD-2 to DD-3). The last PR and BPO inspection occurred on 29 April 2024 at 1930L, the day before the mishap, without any discrepancies noted. (Tabs D-3 and DD-3).

At takeoff on the day of the mishap, there were 7,697.4 hours of total airframe operating time on the MA. (Tabs D-3 to D-10 and DD-2 to DD-3). The engine was last inspected during a combined 100, 200, and 400-hour inspection on 14 December 2022 at 6,432.2 hours of engine in-flight time (IFT). (Tabs J-46, U-19 to U-22, U-45 to U-66, and DD-3). The next 100-hour inspection was scheduled for 6,532.2 hours of engine IFT, the next 200-hour inspection was scheduled for 6,623.2 hours of engine IFT, and the next 400-hour inspection was scheduled for 6,823.2 hours of engine IFT. (Tabs D-11, D-19, D-50 to D-53, and DD-2 to DD-3). At the time of the mishap, the engine core module had accumulated 3620 calculated cycles (CCYs) and was very close to its next scheduled overhaul. (Tabs D-11, D-19, D-50 to D-53, and DD-2 to DD-3).

Before the mishap, the MA had no reported maintenance discrepancies, and all inspections complied with approved Technical Order guidance. (Tabs D-1 to D-3, D-20, J-102, BB-19 to BB-21, and DD-2 to DD-3).

c. Maintenance Procedures

A review of the MA's active and historical AFTO 781 series forms and IMDS revealed that all maintenance actions complied with procedures. (Tabs D-1 to D-22, BB-21, and DD-2 to DD-3).

d. Maintenance Personnel and Supervision

Before the flight, personnel of the 849th Aircraft Maintenance Squadron (AMXS) performed all required inspections, documentation, and servicing. (Tabs D-3 to D-4, D-6 to D-8, and DD-2 to DD-3). Pre-launch procedures were routine, with no indication of any abnormal conditions. (Tabs V-8.2 and V-8.3). While personnel involved with the MA's preparation for flight recently completed training, they all were qualified and had appropriate maintenance supervision to perform their assigned tasks. (Tabs T-1 to T-17).

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

An Air Force Petroleum Office (AFPET) laboratory report on fuel samples taken from the MA at the mishap site showed no indications of volatile contamination. (Tabs D-47 to D-48 and DD-2). Hydraulic fluid servicing documentation in AFTO 781 series forms was standard, and no recent servicing was necessary. (Tabs D-4, D-6 to D-8, J-21, and DD-2). Joint Oil Analysis Program (JOAP) sample analysis leading up to the mishap was within allowable limits. (Tabs D-49 and DD-2). Due to the MA's impact and explosion, only a limited quantity of fuel samples was available for inspection. (Tab J-20). All other fluids could not be collected, including any from the jettisoned and recovered external fuel tank. (Tabs D-48, J-20, and DD-2).

AFTO 781 series forms documentation indicated no hydraulic, oil, or oxygen system servicing was required or performed within the 24-hours before the MA flight. (Tabs D-4, BB-21, and DD-2 to DD-3). The Crash Survivable Flight Data Recorder (CSFDR) data did not record any fuel, hydraulic, or engine oil component malfunctions before the engine loss of thrust. (Tabs J-19 to J-22).

f. Unscheduled Maintenance

Unscheduled maintenance is any action not resulting from a scheduled inspection. (Tabs D-6 to D-8, BB-24, and DD-2). Unscheduled maintenance is usually the result of a pilot-reported discrepancy during flight operations, or a condition discovered by ground maintenance personnel. (Tabs D-6 to D-8 and DD-2).

While installed in a different aircraft, this specific Pratt & Whitney (P&W) F100-PW-220 engine (Figure 5) experienced a foreign object damage (FOD) event in August 2022. (Tabs J-75, BB-26 to BB-27, and DD-2). Damage from this event was limited to only the first stage of the inlet fan – the inlet fan consists of stages one through three of the engine's thirteen stages of compression. (Tabs J-76, V-9.3, V-10.3, 10.5, and DD-2). As required in the applicable AFTOs, repairs were limited to blending the first stage blade damage to within allowable limits. (Tabs U-45 to U-66, V-10.5, V-10.6, BB-26 to BB-27, and DD-2).

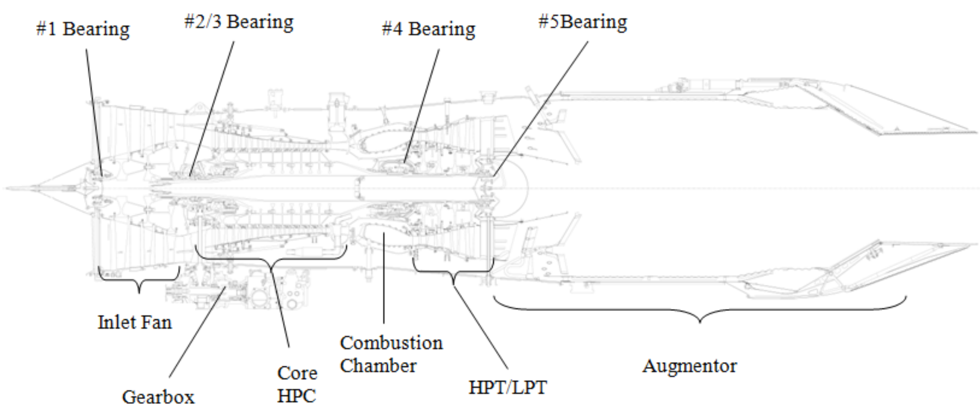

Figure 5. The Pratt & Whitney F100-PW-220 engine (Tab J-45)

Following these repairs, the engine was subjected to borescope inspections where a camera was inserted into access ports, looking for nicks and cracks on blades and vanes. (Figure 6) (Tabs V-10.2 to V-10.4, and BB-26 to BB-27).

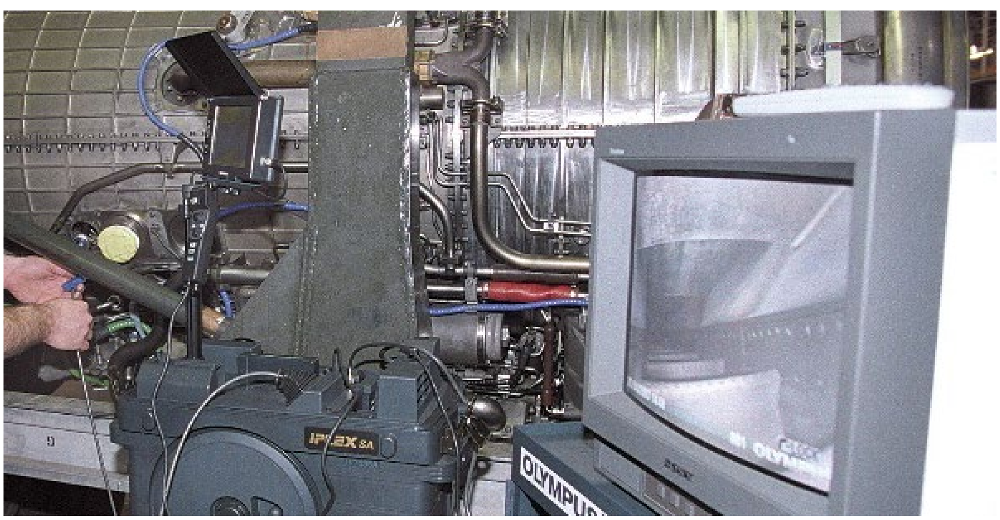

Figure 6. Borescope inspection of an unknown engine type (U.S. Air Force stock photo)

While completing inspections of the inlet fan's first stage FOD repair, 49 MXS also accomplished 100, 200, and 400-hour borescope inspections. (Tabs U-19 to U-22 and DD-2). The inspections on 14 December 2022 at 6,432.2 hours of engine IFT noted no discrepancies in any of the borescope inspectable engine stages, and depot-level maintenance, was not required. (Tabs U-19 to U-22, U-45 to U-66, and DD-3).

Due to the F100-PW-220 engine's absence of an access port permitting a fifth stage borescope inspection, the fifth stage is only inspected through engine core teardown and HPC disassembly accomplished during depot-level maintenance at Tinker AFB, OK. (Tabs V-9.4, V-10.1 to V-10.6, V-11.2, V-12.6, V-13.5, and DD-3). A depot-level inspection of the MA engine's fifth stage was not prescribed after the FOD event due to the absence of damage to the second through fourth stages as well as the sixth stage and beyond. (Tabs U-19 to U-22, U-45 to U-66, and DD-3).

There were no engine unscheduled maintenance discrepancies since the FOD event repairs and inspections discussed in this section and in paragraph 5.b. (Tabs U-19 to U-22, U-45 to U-66, and DD-2 to DD-3).

6. AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS

a. Structures and Systems

(1) Structure

Major MA structures, as well as significant components, were in the general vicinity of the impact location. (Tabs J-6). However, pieces of the MA were scattered in a fan-shaped area to the south about five hundred ft out, with most of the engine in one piece, lying on the face of the sand dune adjacent to the right-hand aft strake, horizontal tail, and right speed brake. (*see*, Figures 3 and 4 in Section 4.e., *Sequences of Events*, *Impact*). (Tab J-6).

(2) Hydraulic System

Based on the CSMU data, both hydraulic systems were pressurized and provided hydraulic power through impact. (Tabs J-19 to J-20).

(3) Electrical System

CSMU data shows the electrical system operated normally until engine RPM decreased, and the main and standby generators dropped offline. (Tabs J-20 to J-23). The emergency power unit (EPU) was automatically activated. (Tabs J-20 to J-23). The EPU is a self-contained system that provides emergency hydraulic and electrical power, and data shows it operated normally during the mishap. (Tab J-23).

(4) Fuel System

CSMU data was used to analyze the fuel system, and the last recorded fuel quantities in the CSMU were 3,200 pounds FR [front right], 2,816 pounds AL [aft left], and 7,104 total pounds at the time of impact. (Tab J-18). The data suggests the 300-gallon external fuel tank was empty as the front right and total fuel quantity did not show a decrease in fuel upon external fuel tank jettison. (Tabs J-18 and Z-8). Fuel was available to the engine throughout the recorded data. (Tab J-18).

b. Other Analysis and Evaluation

(1) Analysis of Digital Flight Control Computer (DFLCC) Data

There were no indications of a degraded flight control system, electrical system, hydraulic system, or DFLCC system failures to suggest a controllability issue. (Tabs J-73, J-75 to J-76, and J-79).

(2) Analysis of Crash Survivable Flight Data Recorder (CSFDR) Data

Data recovered from the CSFDR showed that sixteen seconds after the MP moved the throttle from AB to the Mil power setting, the MA registered an engine loss of thrust. (Figure 7) (Tabs J-12 and Z-7). Data before that point showed normal in-flight engine parameters. (Tab J-12).

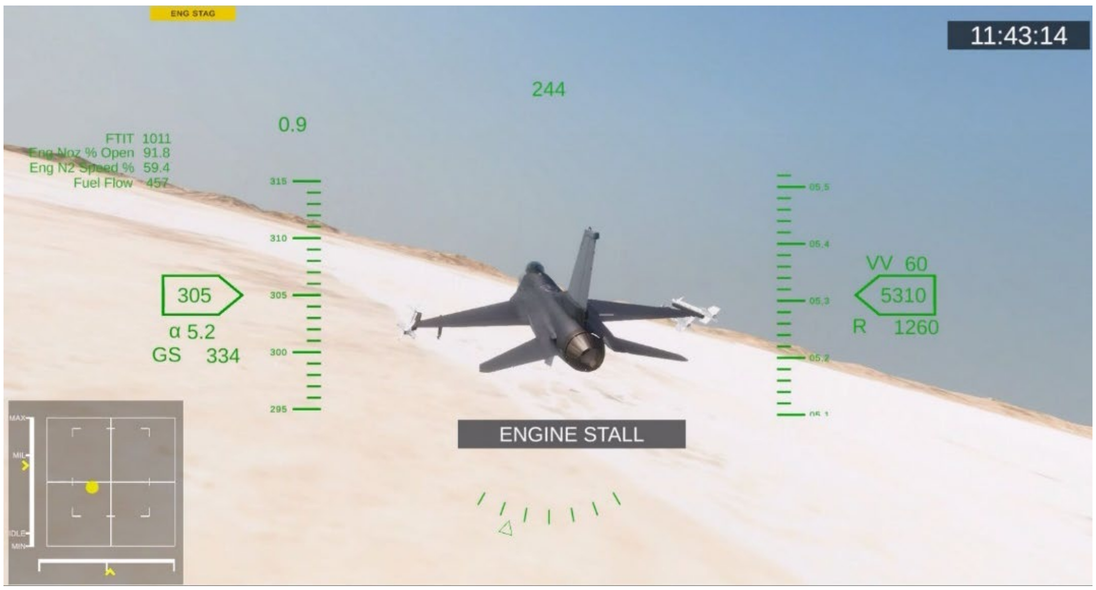

Figure 7. Recorded flight data animation frame capture (Tab Z-7)

(3) Analysis of the Engine

After the unscheduled maintenance and borescope inspections in December 2022 due to the first stage FOD, the engine spent seven months in storage and was installed into the MA on 7 July 2023. (Tab DD-2). Over the following ten months, the engine accumulated 70 hours of engine IFT. (Tabs D-3, U-19 to U-22, and DD-2). The MA's engine was 28.1 hours of engine IFT away from the next 100-hour borescope scheduled inspection. (Tabs D-3, D-11, D-19, and DD-2).

The engine was last overhauled at the Tinker AFB depot in 2016, where no defects were noted. (Tabs J-46, U-23 to U-44, and DD-2). Since then, the engine accumulated 3,620 CCYs and was approaching its next scheduled depot overhaul. (Tab DD-2).

The AIB evaluated three engineering technical analysis reports with engine-related information. (Tabs J-1, J-45, and J-70). All three identified the engine loss of thrust, and two reports noted a separated fifth stage fan blade. (Tabs J-5, J-45, J-70, J-74 to J-75).

(i) Analysis 1: Lockheed Martin Aeronautics Company (Fort Worth, Texas)

As the aircraft manufacturer, Lockheed Martin (LM) provided the flight and performance data required to rule out situations with other systems. (Tabs J-1 to J-44). All MA systems were functioning normally until the loss of thrust at 1143:09L. (Tab J-5 and J-12). Following the loss of thrust, all MA systems responded as designed, with a few minor exceptions noted in the LM report, none of which prevented the safety of the MA's flight. (Tabs J-5).

(ii) Analysis 2: Air Force Life Cycle Management Center (AFLCMC) Propulsion Directorate (Tinker AFB, Oklahoma)

The AFLCMC Propulsion Directorate at Tinker AFB assisted in the teardown and inspection of the MA's recovered engine. (Tabs J-57, J-68 to J-69, and DD-2). The technical and engineering analysis showed no pre-impact damage forward of the fifth stage. (Tab J-69). The report concluded the single fifth stage HPC blade separated, (Figure 8) causing severe secondary damage to other blades in the fifth stage and several following stages. (Tab J-68).

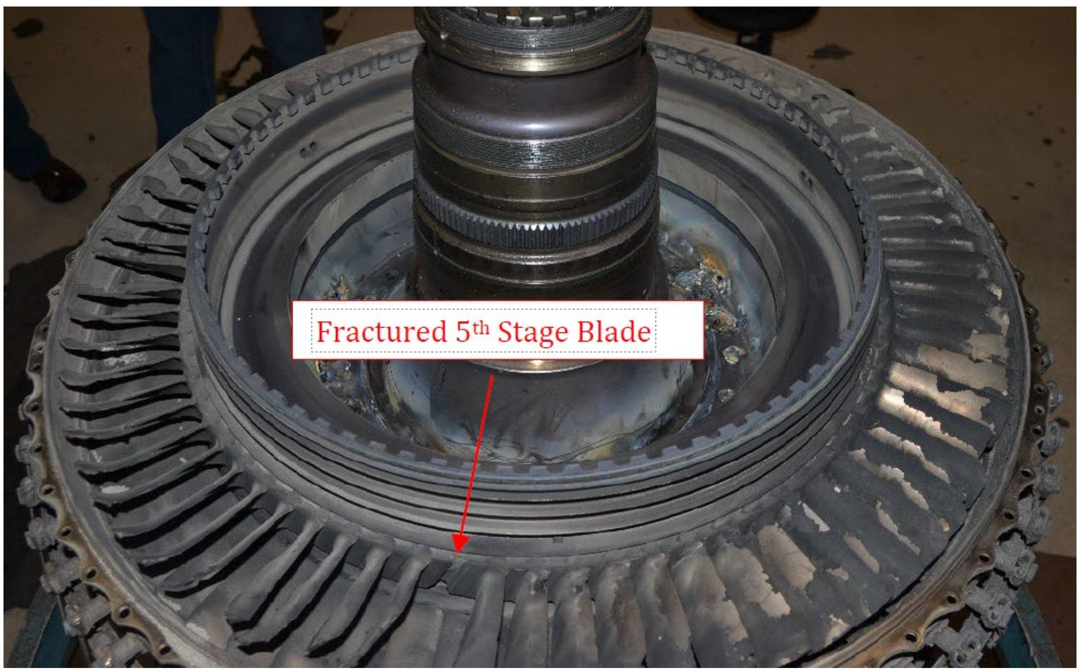

Figure 8. Fifth stage separated (or "fractured") HPC blade (Tab J-57)

(iii) Analysis 3: Pratt & Whitney (P&W) (East Hartford, Connecticut)

As the engine manufacturer, P&W concluded the engine loss of thrust was caused by a significant disruption of airflow due to the fifth stage HPC blade separation. (Figure 9) (Tabs J-72 and J-73).

Figure 9. Fifth stage separated (or "fractured") HPC blade (Tab J-75)

However, P&W also found airflow disturbances from a turned fifth stage variable vane, which over time, resulted in high-cycle fatigue of the blade. (Figure 10) (Tabs J-101 and CC-3 to CC-4).

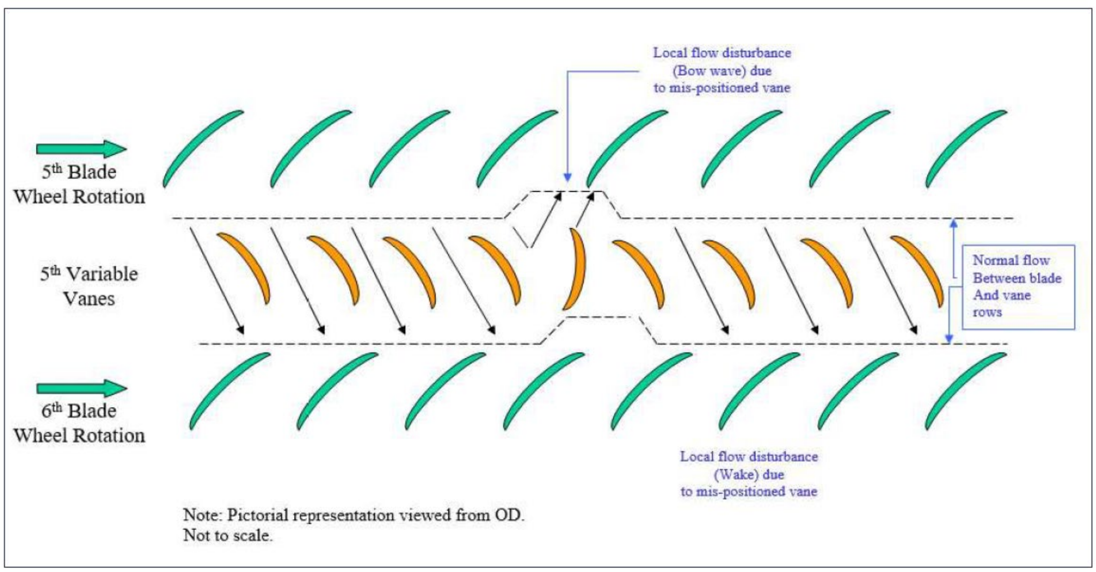

Figure 10. Representation of a turned fifth stage variable vane effect on blades (Tab J-106)

A faint vane wake mark pattern (*i.e.* dirt deposits that occur during flow separation of upstream air) on the vane set's shroud, or housing, was irregular, suggesting the number ten position vane operated in the turned position (about twenty-five degrees more open than adjacent vanes) before the blade fracture event. (Figure 11) (Tabs J-97 and J-101).

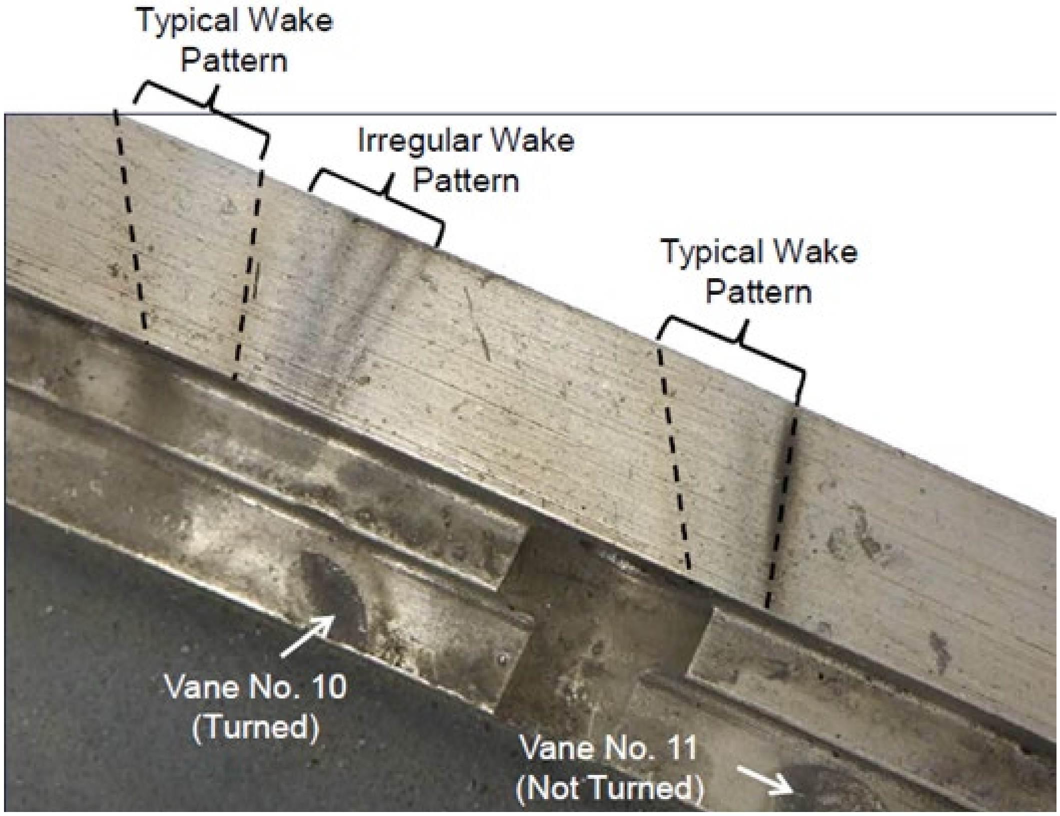

Figure 11. Irregular wake pattern from Vane No. 10 (Tab J-101)

Analysis by P&W of engine damage events over the past twenty years showed six instances of turned HPC vanes causing cracked or fractured blade roots and disk lugs. (Tab J-105). The probable cause of the turned vane(s) in three of the six instances was from being misassembled or other maintenance activity. (Tab J-105). In two of the six instances, the probable cause of the turned vane(s) was FOD or Domestic Object Damage (DOD), where other pieces of the engine separated (like a bolt coming loose), causing damage. (Tabs J-105 and V-13.7). Only one of the six occurrences included a turned vane in the fifth stage, and it was FOD / DOD related. (Tabs J-72 and J-105). The probable cause for the remaining instance was unknown. (Tab J-105).

(4) Evaluation of the Engine Analysis

The turned fifth stage variable stator vane produced abnormal aerodynamic forces, resulting in high-cycle fatigue and eventual separation of the fifth stage HPC blade. (Tabs J-73 and CC-3 to CC-4). Low amplitude, high-frequency elastic strains characterize HCF – an example would be an airfoil subjected to repeated bending. (Tab CC-4). The debris from the HPC blade separation caused a significant airflow disruption causing the engine loss of thrust at 1,030 ft AGL. (Tabs J-73, L-1 to L-2, and Z-6).

A field-level engine maintainer with forty-three years of experience on F100 engines testified that the turning of one out of the sixty-two fifth stage vanes could be from being misassembled at the depot (Tabs V-9.2, V-9.5, and DD-2). However, the depot engine professionals (a maintainer with eight years of depot experience, a supervisor, and an aerospace engineer) all testified regarding quality control processes and how a misaligned vane would result in the entire variable vane set binding during prescribed checks as the vanes all move in unison. (Tabs V-11.2 to V-11.3, V-12.2, V-12.8 to 12.9, V-13.1 to V-13.4, V-13.6, and DD-2). The MA's engine also made it through nearly all its scheduled maintenance cycle before the mishap occurred. (Tabs J-76 and DD-2 to DD-3). While considering the historical instances of turned vanes, the P&W report did not present evidence of a vane being misassembled in the MA engine. (Tabs J-72 and J-105).

Furthermore, while the MA's engine had a prior FOD event in August 2022, no evidence of pre-impact FOD was present in the P&W report. (Tabs J-72, J-102, J-105, and DD-2 to DD-3).

7. WEATHER

a. Forecast Weather

On 30 April 2024, the Holloman AFB mission execution forecast showed variable winds at six knots, ten statute miles of visibility, and clear skies. (Tabs F-1 to F-2). The forecast in the planned airspace showed surface winds out of the west at 12 knots with gusts up to 18 knots. (Tabs F-1 to F-2). Planned flight level winds were at 15 knots out of the west, seven statute miles of visibility, skies clear, and no other significant weather. (Tabs F-1 to F-2).

b. Observed Weather

A meteorological aerodrome report from 1748 Zulu (1148L) reported variable winds at six knots, visibility of 10 statute miles, and clear skies at the time of the mishap. (Tab F-3).

c. Space Environment

Not Applicable.

d. Operations

Given the clear skies and light winds, weather was not a factor in this mishap. (Tabs F-1 to F-3).

8. CREW QUALIFICATIONS

a. Mishap Pilot

At the time of the mishap, the MP was a current and qualified F-16 FTU IP with 700.9 total flying hours (Tab G-5). The MP's last periodic instrument and qualification check ride was completed on 15 September 2023. (Tab G-47). The MP's initial instructor and periodic mission check ride were completed on 13 February 2024. (Tab G-47). The MP earned a qualification level-one in all these evaluations with no downgrades or discrepancies. (Tabs G-48 to G-51). The MP's last sortie before the mishap was 26 April 2024. (Tab G-7).

The recent flight time for the MP is as follows (Tab G-4):

MP	Hours	Sorties
Last 30 days	6.2	5
Last 60 days	24.8	19
Last 90 days	33.4	26

b. Other USAF Pilots

Not applicable.

9. MEDICAL

a. Qualifications

The MP was medically qualified to fly. (Tab DD-4). The Aeromedical Services Information Management System showed the MP had a current DD Form 2992, *Medical Recommendation for Flying or Special Operation Duty*, requiring him to wear vision correction devices during flight duties. (Tab DD-4). The MP has one aeromedical waiver, approved on 8 June 2016, with an indefinite expiration. (Tab DD-4). The MP had a Periodic Health Assessment on 28 April 2023 and was in good health at the time of the mishap. (Tab DD-4). MP's medical background was not a factor in this mishap. (Tabs V-1.2 to V-1.3 and DD-4).

The MP complained of neck pain and right ankle pain following the mishap and was confirmed to have suffered non-life-threatening injuries. (Tabs V-1.12 to V-1.15 and DD-4). The MP had no disqualifying or pre-existing medical conditions that could have affected the outcome of the mishap. (Tab DD-4). When interviewed, the MP reported no recent illness that could have affected his responses or actions during the mishap. (Tabs V-1.2 to V-1.3).

b. Health

The 72-hour and 14-day histories for all relevant aircrew and maintenance personnel revealed no significant health concerns. (Tabs R-1 to R-14 and DD-4). There is no evidence suggesting the health of these individuals was relevant to the mishap. (Tabs V-1.2 to V-1.3, V-8.9, and DD-4).

c. Toxicology

Immediately following the mishap, commanders directed toxicology testing for all personnel involved in the flight and the launch of the MA. (Tab DD-4). Blood and urine samples were submitted to the Armed Forces Institute of Pathology for toxicological analysis. (Tab DD-4). Toxicology reports were reviewed, and no discrepancies were found. (Tab DD-4).

d. Lifestyle

There is no evidence the MP or maintenance crew members' habits, behaviors, or stressors contributed to this mishap. (Tab DD-4). Witness testimonies, as well as 72-hour and 14-day histories, revealed no evidence that lifestyle factors contributed to the mishap, including unusual habits, behavior, or stress. (Tabs V-1.2 to V-1.3, V-8.9, and DD-4).

e. Crew Rest and Crew Duty Time

Air Force Manual (AFMAN) 11-202V3, *Flight Operations*, includes crew rest and crew duty time requirements. (Tab BB-9). Crew rest is compulsory for aircrew members before performing any duties involving aircraft operations and is a minimum of 12 non-duty hours before the flight duty period (FDP) begins. (Tab BB-9). Crew rest consists of free time and time for meals, transportation, and rest. (Tab BB-9). Crew rest time must include an opportunity for at least eight hours of uninterrupted sleep. (Tab BB-9). Aircrew are each individually responsible for ensuring sufficient rest during crew rest periods. (Tab BB-9). The MP had more than 12-hours of crew rest before the mishap FDP and had the opportunity for at least eight hours of uninterrupted sleep, thus meeting the requirements. (Tab BB-9).

Before the mishap, the MP met crew rest and crew sleep requirements. (Tabs V-1.2 to V-1.3, BB-9, and DD-4). The MP stated fatigue did not affect his reaction time or decision-making abilities. (Tabs V-1.2 to V-1.3, BB-9, and DD-4). The MP obtained eight hours of sleep before the mishap, slept continuously, and felt well-rested the day of the mishap. (Tabs V-1.2 to V-1.3, BB-9, and DD-4).

10. OPERATIONS AND SUPERVISION

a. Operations

The MP was conducting an F-16 basic course BSA syllabus training sortie with two F-16 student pilots in formation. (Tabs G-20, V-2.6, and V-2.12). The planned 8 FS operations turn pattern for the day was a routine eight-turn-eight, in which the squadron flew eight aircraft in the first takeoffs of the day and intended to fly another eight later in the day. (Tab G-20).

b. Supervision

Supervision of 8 FS operations on the day of the mishap was assigned to the Operations Supervisor, also called "Top 3." (Tab V-5.8). The flight had all required authorization, supervision, and documentation for the mission. (Tab V-5.4). A Supervisor of Flying was on duty in the control tower, and "Top 3" was at the 8 FS building. (Tabs V-4.14 and V-5.8). Along with the rest of the formation pilots, the MP had a valid flight authorization endorsed by the "Top 3" responsible for executing the day's 8 FS operations, planning, and scheduling. (Tab G-20).

11. HUMAN FACTORS ANALYSIS

a. Introduction

The Department of Defense Human Factors Analysis and Classification System 8.0 lists potential human factors that can play a role in aircraft mishaps and identifies possible areas of assessment during a mishap investigation. (Tabs BB-10 to BB-14). There is no evidence that human factors contributed to the cause of this mishap. (Tabs BB-10 to BB-14).

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Publicly Available Directives and Publications Relevant to the Mishap

(1) AFI 51-307, *Aerospace and Ground Accident Investigations*, dated 18 March 2019

(2) AFMAN 11-2F-16V1, *F-16 Aircrew Training*, dated 17 June 2019 (incorporating Change 2, dated 8 August 2022, and Certified Current on 8 August 2022) (NOTE: A revised baseline AFMAN is dated 26 June 2024, after the date of the mishap)

(3) AFMAN 11-2F-16V2, *F-16 Aircrew Evaluation Criteria*, dated 8 February 2019

(4) AFMAN 11-2F-16V3, *F-16 Operations Procedures*, dated 4 February 2020

(5) AFMAN 11-202V1, *Aircrew Training*, dated 27 September 2019

(6) AFMAN 11-202V2, *Aircrew Standardization and Evaluation Program*, dated 30 August 2021

(7) AFMAN 11-202V3, *Fight Operations*, dated 10 January 2022

(8) DAFI 91-204, *Safety Investigations and Reports*, dated 10 March 2021

(9) Department of Defense Human Factors Analysis and Classification System 8.0 (https://www.safety.af.mil/Divisions/Human-Performance-Division/ HFACS/)

(10) Federal Aviation Administration, *Pilot's Handbook of Aeronautical Knowledge* (https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/phak)

(11) Holloman AFB Instruction 21-370, *Foreign Object Debris/Damage Prevention Program*, dated 12 November 2019

(12) Holloman AFB Instruction 11-250, *Airfield Operations and Base Flying Procedures*, dated 12 March 2018

NOTE: The guidance listed above that does not list a web address is available digitally on the Air Force Departmental Publishing Office website at: https://www.e-publishing.af.mil.

b. Other Relevant Guidance, but Not Publicly Available

(1) 1F-16CM-1, *Flight Manual*, dated 15 June 2023

(2) 1F-16CM-34-1-1, *Avionics and Nonnuclear Weapons Delivery Flight Manual*, dated 1 September 2022 (Interim Supplement, dated 1 February 2023)

(3) F-16CG-2-70FI-00-21, *Fault Isolation Organizational Maintenance Power Plant Model F100-PW-220 / 220E USAF Series F-16C and F-16D Aircraft*, dated 1 February 2024

(4) 49th Wing In-Flight Guide, dated 27 October 2022

c. Known or Suspected Deviations from Publications and Directives

No known or suspected deviations from publications and directives apply to the mishap's cause, substantially contributing factor, or outcome.

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JAMES B. STEWART, Colonel, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

F-16C, T/N 87-0358
HOLLOMAN AIR FORCE BASE, NEW MEXICO
30 APRIL 2024

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 30 April 2024, at approximately 1144 hours local time, an F-16C with tail number (T/N) 87-0358 crashed six and a half nautical miles southwest of the departure end of Runway 25, Holloman Air Force Base, New Mexico. The flight was planned and authorized as a Basic Surface Attack training mission within the local airspace. The weather was clear skies with unrestricted visibility and light winds out of the west. Thirty-six seconds after take-off, the mishap aircraft (MA) experienced an engine loss of thrust while at 1,030 feet (ft) Above Ground Level (AGL). The mishap pilot (MP) initiated corrective actions, and one minute and eighteen seconds after the engine loss of thrust, the MP ejected. Shortly after the MP's ejection, the MA was destroyed upon impact within White Sands National Park, with a total loss valued at $21,702,152. The MP sustained only minor injuries from the ejection and was recovered by an Army Air helicopter within several minutes.

I find, by a preponderance of the evidence, the cause of the mishap was a misaligned or turned number ten position variable stator vane in the fifth stage of the MA engine and the subsequent breaking free of a fifth stage fan blade causing catastrophic engine damage at low altitude with no ability to recover.

I developed my opinion after interviewing witnesses, including experienced field and depot engine maintainers, a Field Training Detachment engine instructor, and an F100-PW-220 aerospace engineer with a primary focus on the engine core module. In addition to interviewing the MP, I interviewed current and qualified F-16 functional check flight, evaluator, and other instructor pilots. I also reviewed applicable maintenance records, Air Force guidance, and other witness testimonies. Finally, I considered flight data animations, listened to radio transmissions, studied engineering analysis reports, viewed the MA wreckage, visited the crash site, and toured the depot engine overhaul facility, all to gather evidence to support my opinion.

2. CAUSE

I find by a preponderance of the evidence that the aircraft mishap was caused by a misaligned or turned number ten position variable stator vane in the fifth stage of the MA's F100-PW-220 engine, resulting in the separation of a fifth stage fan blade.

Over time, this turned vane in the fifth stage caused high cycle fatigue and the eventual separation of a fifth stage high-pressure compressor (HPC) blade. This separated blade caused further engine damage and a significant airflow disruption, resulting in an engine stall and stagnation. The engine loss of thrust while the MA was at 1,030 ft AGL with 329 knots calibrated airspeed in a left, slightly climbing turn, was unrecoverable. The MP's only possible favorable outcome was ejecting before running out of altitude or airspeed.

Maintenance records showed the August 2022 foreign object damage (FOD) event only caused damage to first stage fan blades. Following technical order procedures, fifteen first stage blades were repaired and inspected, and all accessible stages of the engine were inspected. No damage was noted in the second through fourth stages, nor the sixth through thirteenth stages. The fifth stage is not inspected other than during a depot-level maintenance HPC teardown. Field-level maintenance correctly performed all required engine repair and inspection tasks; therefore, the engine was returned to service. No field-level indications would have triggered the removal of the engine for shipping to the depot for unscheduled maintenance of the fifth stage.

The Pratt & Whitney analysis stated the probable sequence of events started with the August 2022 FOD event. Given no damage was noted on stages two through four after the FOD event, I inquired about the likelihood of damage to a later stage with no damage to a prior stage (or stages). A field-level engine maintainer with forty-three years around F100 engines testified, "it happens, it's kind of unexplainable…but it's frequent enough that we all have seen" instances. A field-level engine and borescope instructor had never seen this occur. An experienced depot maintainer said it could happen but was very rare. Finally, a depot aerospace engineer said it would be surprising if it occurred. While historical instances and testimony suggest the possibility of the vane being turned during a field FOD event, I found no evidence this happened.

While possible, it is not likely a single vane would be incorrectly assembled at the depot and subsequently be missed during depot quality assurance inspection processes before or during the HPC and engine core reassembly. All three interviewed depot professionals testified a misaligned vane would cause the whole variable vane set to bind and not pass inspection as the vanes all move in unison. Furthermore, it is unlikely the engine would perform most of its calculated cycles before the next scheduled depot overhaul without incident if the vane were incorrectly assembled during the previous overhaul. While historical instances suggest the possibility of a vane being turned by maintenance activity, I found no evidence of improper maintenance activity.

I find the cause for the turned vane impossible to determine.

3. SUBSTANTIALLY CONTRIBUTING FACTORS

I find by a preponderance of the evidence the following factor substantially contributed to the mishap: the fifth stage of the F100-PW-220 engine is not inspected except during an engine core and HPC teardown at depot-level maintenance.

All five engine professionals I interviewed testified the inspection of the fifth stage occurs at depot-level maintenance during an engine core and HPC teardown. An experienced depot maintainer theorized an extremely lengthy, unprescribed possibility of sneaking a borescope through individual openings in the fourth stage to inspect one of the fifth stage vanes and blades at a time. Each instance would require withdrawing the borescope and sneaking it back through another opening while risking it breaking off inside the engine and causing additional damage. Therefore, this is not a prescribed maintenance procedure.

The known "blind spot" of not inspecting the fifth stage when field procedures do not indicate damage in adjacent stages requires a deliberate risk assessment by the F-16 system program office. The risk assessment is based on the historical and anticipated probability of damage before scheduled maintenance compared to the severity of possible adverse effects. This deliberate risk assessment is informed by the limited time, manpower, and funding available to pull an engine out of an aircraft in the field, ship it to depot-level maintenance, perform a teardown, inspect it and make repairs (if any), reassemble it, ship it back to the field, and reinstall it into an aircraft.

Performing unprescribed, unscheduled maintenance, even if out of an abundance of caution, would adversely affect the whole aircraft program and other programs competing for the same resources. However, it is highly likely this specific mishap might have been avoided if post-FOD event policy or general lifecycle procedures prescribed a shorter deadline for the next depot-level scheduled maintenance.

4. CONCLUSION

I find, by a preponderance of the evidence, the aircraft mishap was caused by a misaligned or turned number ten position variable stator vane in the fifth stage of the MA's F100-PW-220 engine, resulting in the separation of a fifth stage fan blade. I also find the known limitation of the inability to borescope inspect the F100-PW-220 engine's fifth stage, combined with only inspecting the fifth stage during an engine core and HPC teardown at depot-level maintenance, substantially contributed to the aircraft mishap.

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JAMES B. STEWART, Colonel, USAF
President, Accident Investigation Board

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