

UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION
BOARD REPORT



F-16CJ, T/N 91-0340

480TH FIGHTER SQUADRON
52D FIGHTER WING
SPANGDAHLEM AIR BASE, GERMANY



LOCATION: SPANGDAHLEM AIR BASE, GERMANY

DATE OF ACCIDENT: 8 OCTOBER 2019

BOARD PRESIDENT: COLONEL JOHN C. STRATTON

Conducted IAW Air Force Instruction 51-307

ACTION OF THE CONVENING AUTHORITY

The report of the accident investigation board, conducted under the provisions of AFI 51-307, that investigated the 8 October 2019 mishap near Spangdahlem Air Base, Germany, which resulted in the destruction of F-16CJ, T/N 91-0340, assigned to the 480th Fighter Squadron, 52nd Fighter Wing, Spangdahlem Air Base, Germany, complies with the applicable regulatory and statutory guidance and on that basis is hereby approved.



STEVEN L. BASHAM
Lieutenant General, USAF
Deputy Commander

United States Air Force Accident Investigation Board Report

Class A Mishap, Spangdahlem Air Base, Germany

EXECUTIVE SUMMARY UNITED STATES AIR FORCE AIRCRAFT ACCIDENT INVESTIGATION

**F-16CJ, T/N 91-0340
SPANGDAHLEM AIR BASE, GERMANY
8 OCTOBER 2019**

On 8 October 2019, the mishap pilot (MP), flying a F-16CJ, tail number (T/N) 91-0340, assigned to the 480th Fighter Squadron, "the Warhawks," 52d Fighter Wing, Spangdahlem Air Base, Germany, conducted a routine training sortie as part of the wing's local readiness exercise SABER FURY. Shortly after take-off, at 15:10:42 hours local (L) time, the MP ejected from the mishap aircraft (MA) with no injuries. The MA was destroyed upon impact in a forested area at 15:11:24L 8 nautical miles (nm) south of the base. The mishap resulted in zero military or civilian casualties and the loss of a \$25,551,000.00 United States government asset.

The mishap flight was planned and authorized as a suppression of enemy air defenses training mission within the local training airspace. The MP was flying as number two of a scheduled 4-ship formation, but which departed as a 3-ship. The prevailing weather at the airfield, and in the surrounding area, was a ceiling at 500 feet with instrument meteorological conditions (IMC) up to 15,000 feet. Approximately 13 seconds after take-off, during the transition to IMC, the MA experienced a power disruption causing a partial electrical power loss (also known as an electrical "brownout") which failed the MP's primary flight and navigation instruments without corresponding fault or failure indications. This power disruption also caused the embedded global positioning and inertial navigation set (EGI) to lose power and remain off-line. The subsequent degradation and mismatch in data between the primary and standby instruments caused the pilot to become spatially disoriented at low altitude and in IMC. After two failed attempts to activate the pilot activated recovery system, following two instances of visually acquiring trees below the 500-foot ceiling, the MP successfully egressed the aircraft.

The Accident Investigation Board President found, by a preponderance of the evidence, the cause of the mishap was the combination of two factors. First, the MA experienced a partial electrical power loss (brownout). The power loss caused a cascading failure of the EGI and the MP's primary flight and navigation instruments. Due to the EGI's loss of power, the primary attitude direction indicator continued to display unreliable data without fault or failure indications and prevented the MP from transitioning fully to the standby attitude indicator for attitude reference. Second, the weather conditions at the time of the power disruption caused the MP to rely on his primary and standby flight instruments to maintain aircraft control during a critical phase of flight. The mismatch in data provided by the primary and standby attitude indicators, due to the power disruption, caused the MP to become spatially disoriented and unable to maintain aircraft control in the weather and at low altitude. The absence of either factor may have prevented this mishap.

Under 10 U.S.C. § 2254(d) the opinion of the accident investigator as to the cause of, or the factors contributing to, the accident set forth in the accident investigation report, if any, may not be considered as evidence in any civil or criminal proceeding arising from the accident, nor may such information be considered an admission of liability of the United States or by any person referred to in those conclusions or statements.

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SUMMARY OF FACTS AND STATEMENT OF OPINION

F-16CJ, T/N 91-0340

8 OCTOBER 2019

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ACRONYMS AND ABBREVIATIONS

480 FS	480th Fighter Squadron	EGI	Embedded Global Positioning and Inertial Navigation Set
52 FW	52d Fight Wing	EHSI	Electronic Horizontal Situation Indicator
52 OG	52d Operations Group	EOR	End of Runway
52 OSS	52d Operations Support Squadron	EPOD	Emergency Procedure of the Day
AC	Alternating Current	FDP	Flight Duty Period
ADAC	Allgemeiner Deutscher Automobil-Club	FDR	Flight Data Recorder
AB	Air Base	FL	Flight Level
ACES II	Advanced Concept Ejection Seat	FLCS	Flight Control System
ACMI	Air Combat Maneuvering Instrumentation	G	Gravitational Force
ADAC	General German Automobile Club	GE	Germany
ADI	Attitude Director Indicator	GLOC	G-Induced Loss of Consciousness
AFE	Aircrew Flight Equipment	Go/No Go's	Currency Check
AFI	Air Force Instruction	GPS	Global Positioning System
AFTO	Air Force Technical Order	HARM	High-speed Anti-Radiation Missile
AGCAS	Automatic Ground Collision Avoidance System	HFACS	Department of Defense Human Factors Analysis and Classification System 7.0
AGL	Above Ground Level	HMCS	Helmet Mounted Cueing System
AIB	Accident Investigation Board	HTS	HARM Targeting System
AOA	Angle of Attack	HUD	Heads-Up Display
ARMS	Aviation Resource Management System	IAW	In Accordance With
ATAGS	Advanced Technology Anti-Gravity Suit	IFF	Introduction to Fighter Fundamentals
AUTO	Automatic	IMC	Instrument Meteorological Conditions
AUX	Auxiliary	IMDS	Integrated Maintenance Data System
BPO	Basic Post-Flight	KCAS	Knots Calibrated Airspeed
BULLSEYE	Known Common Reference Point	KEAS	Knots Equivalent Airspeed
CADC	Central Air Data Computer	L	Local Time
CFIT	Controlled Flight Into Terrain	LM	Lockheed Martin
CMR	Combat Mission Ready	Lt Col	Lieutenant Colonel
CSFDR	Crash Survivable Flight Data Recorder	MA	Mishap Aircraft
CSMU	Crash Survivable Memory Unit	METAR	Meteorological Aerodrome Report
CT	Continuation Training	MF1	Mishap Flight Lead
DFLCS	Digital Flight Control System	MF	Mishap Flight
DoD	Department of Defense	MFDs	Multifunction Display Sets
ECM	Electronic Countermeasure	MFL	Maintenance Fault List
EFB	Electronic Flight Book	MIL	Military Power
		MMC	Modular Mission Computer
		MOPP	Mission Oriented Protective Posture
		MP	Mishap Pilot

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MQT	Mission Qualification Training	SEAD	Suppression of Enemy Air Defenses
MSL	Barometric Altitude	SIB	Safety Investigation Board
MUX	Multiplex	SJA	Staff Judge Advocate
NATO	North Atlantic Treaty Organization	SME	Subject Matter Expert
NAV	Navigation	SOF	Supervisor of Flying
NM	nautical miles	SQ/CC	Squadron Commander
NOTAMS	Notices to Airmen	STAPAC	Pitch Control Stabilization Assembly
ORM	Operational Risk Management	TCTO	Time Compliance Technical Order
PARS	Pilot Activated Recovery System	T/N	Tail Number
PAS	Protective Aircraft Shelter	TO	Technical Order
PFL	Pilot Fault List	Top 3	Squadron Supervision
PFLD	Pilot Fault List Display	UPT	Undergraduate Pilot Training
PHA	Periodic Health Assessment	USAFE-AFACRICA	United States Air Forces in Europe-
PIREP	Pilot Report		Air Forces Africa
PLB	Personnel Locator Beacon	USAFRICOM	United States Africa Command
PR	Pre-Flight		
PRD	Pilot-Reported Discrepancy	USEUCOM	United States European Command
PWC	Pilot Weather Category		
SAI	Standby Attitude Indicator	WAI	Walk-Around Inspection
SAU	Signal Acquisition Unit	Z	Zulu Time
SAMS	Surface-to-Air Missile Systems		
SD	Spatial Disorientation		

The above list was compiled from the Summary of Facts, the Statement of Opinion, the Index of Tabs, and Witness Testimony (Tabs R and V).

PSEUDONYMS

Flight Lead/Aircraft #1 – MF1

Mishap Pilot – MP

Mishap Flight Aircraft #3 – MF3

Squadron Commander – Lt Col SQ/CC

Supervisor of Flying – SOF1

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SUMMARY OF FACTS

1. AUTHORITY AND PURPOSE

a. Authority

On 30 October 2019, Lieutenant General Steven L. Basham, the Deputy Commander, United States Air Forces in Europe-Air Forces Africa (USAFE-AFAFRICA), appointed Colonel John C. Stratton to conduct an aircraft accident investigation of the 8 October 2019 mishap of an F-16CJ aircraft at Spangdahlem Air Base (AB), Germany (GE) (Tab Y-3 to Y-4). Part 1 of the Safety Investigation Board (SIB) was given to the Accident Investigation Board (AIB) on 5 November 2019 at Spangdahlem AB, GE. The appointed members present for the hand-off were Colonel Stratton, a Major legal advisor, and a Master Sergeant recorder. A Captain pilot member, a Senior Master Sergeant maintenance member, and a Lieutenant Colonel medical member were appointed to the AIB by the Staff Judge Advocate (SJA), USAFE-AFAFRICA, on 1 November 2019 (Tab Y-5 to Y-6). Due to a conflict of interest, a new Captain pilot member was appointed to the AIB by the SJA on 4 November 2019 (Tab Y-7 to Y-8). The Lieutenant Colonel medical member, Captain pilot member, and Senior Master Sergeant maintenance member arrived at Spangdahlem AB, GE, on 5 November 2019. The board conducted the accident investigation at Spangdahlem AB, GE, from 6 November 2019 to 20 November 2019.

b. Purpose

In accordance with (IAW) Air Force Instruction (AFI) 51-307, *Aerospace and Ground Accident Investigations*, dated 18 March 2019, the AIB conducted a legal investigation to inquire into all 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 8 October 2019, the mishap pilot (MP), flying a F-16CJ, tail number (T/N) 91-0340, assigned to the 480th Fighter Squadron, "the Warhawks," 52d Fighter Wing, Spangdahlem AB, GE, engaged in a local training mission in support of exercise SABER FURY (Tabs R-18 and T-4). Approximately 13 seconds after take-off, during the transition to instrument meteorological conditions (IMC), the mishap aircraft (MA) experienced a power disruption causing a partial electrical power loss (also known as an electrical "brownout") which failed the MP's primary flight and navigation instruments without corresponding fault or failure indications (Tab J-25 and J-47). These failures, coupled with being in the clouds and close to the ground, led to recognized spatial disorientation the MP deemed unrecoverable (Tab R-22 to R-23). The MP successfully ejected and the MA impacted the ground approximately 8 nautical miles south of the runway at 15:11:24.87 local time (L) (Tab J-27, J-30 and J-49). The mishap resulted in zero military or civilian casualties and the loss of a \$25,551,000.00 United States government asset (Tab O-3).

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3. BACKGROUND

a. UNITED STATES ARMED FORCES IN EUROPE – AIR FORCES AFRICA (USAFE-AFAFRICA)

USAFE-AFAFRICA, headquartered at Ramstein AB, GE, is a major command of the U.S. Air Force. It is the air component for two Department of Defense unified commands – United States European Command (USEUCOM) and U.S. Africa Command (USAFRICOM) (Tab CC-3). As the air component for both USEUCOM and USAFRICOM, USAFE-AFAFRICA executes the Air Force, USEUCOM and USAFRICOM missions with forward-based airpower and infrastructure to conduct and enable theater and global operations (Tab CC-3). USAFE-AFAFRICA directs air operations in a theater spanning three continents, covering more than 10 million square miles, containing 104 independent states, possessing more than one-fifth of the world's population, and more than a quarter of the world's gross domestic product (Tab CC-3).



b. 52d Fighter Wing (52 FW)

The 52 FW, located at Spangdahlem AB, GE, maintains, deploys, and employs F-16 Fighting Falcon fighter aircraft and \$6 billion of U.S. Protection Level 1 assets in support of North Atlantic Treaty Organization (NATO) and national defense directives (Tab CC-5). The wing is organized into five groups responsible for operations, maintenance, mission support, medical operations and munitions maintenance (Tab CC-5). The wing provides support to the 726th Air Mobility Squadron as it sustains air mobility operations throughout Europe, Africa and Southwest Asia (Tab CC-5). The wing supports the Supreme Allied Commander, Europe, with 5,000 mission-ready military and civilian personnel in 16 squadrons providing support to 7 geographically separated units, 13 real property sites and 8 tenant units in 5 nations across Europe promoting regional stability (Tab CC-5).



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c. 52d Operations Group (52 OG)

The 52 OG is paramount to ensuring the suppression of enemy air defenses (Tab CC-8). It deters aggression with combat-ready Airmen capable of executing the full spectrum of their mission taskings and capabilities (Tab CC-8). It also develops strategic partnerships and capabilities through integrated training and exercise opportunities (Tab CC-8). Additionally, it demonstrates resolve and commitment to our NATO/European allies through forward presence and the ability to employ airpower, enable global mobility, and accept combat ready forces (Tab CC-8). The 52 OG is organized into three squadrons: 480th Fighter Squadron (480 FS), 52d Operations Support Squadron (52 OSS), and 52 OG, Detachment 1 (Tab CC-8).



d. 480th Fighter Squadron (480 FS)

The 480 FS is USAFE's only suppression of enemy air defenses (SEAD) squadron, providing airpower Operations to NATO, USEUCOM, and USAFRICOM with a "Combat Ready" F-16 squadron prepared to deploy combat airpower in support of Joint, NATO and coalition taskings (Tab CC-8). The squadron operates the F-16 C/D Fighting Falcon with pilots trained to perform the "Wild Weasel" mission of suppression or destruction of enemy air defenses, and are also trained for interdiction and counter air operations (Tab CC-6). Their F-16s are outfitted with high-speed anti-radiation missiles (HARM), joint direct attack munitions, laser-guided bombs, global positioning system (GPS) guided-inertial aided munitions and the HARM targeting system (HTS) pod, making the aircraft a lethal platform against enemy air defense systems (Tab CC-6).



e. F-16 Fighting Falcon

The F-16 Fighting Falcon is a compact, multi-role fighter aircraft (Tab CC-10). It is highly maneuverable and has proven itself in air-to-air combat and air-to-surface attack (Tab CC-10). It provides a relatively low-cost, high performance weapon system and aerial demonstration platform for the United States and allied nations (Tab CC-10).



4. SEQUENCE OF EVENTS

a. Mission

The mishap flight (MF) was a formation of four F-16CJs, call-sign "Warhawk 11" (Tab T-4). Due to an aircraft instrument malfunction prior to take-off, the number 3 aircraft (MF3) in the MF remained at Spangdahlem AB, while the rest of the flight departed as a 3-ship (Tab V-1.1). The MP/MA was number two, call-sign "Warhawk 12," of the formation (Tab T-4). This was the MF's

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second flight of the day as all flights were scheduled to double-turn (Tab T-3 to T-4). The mission was a continuation training (CT) flight executing a SEAD mission, in support of exercise SABER FURY (Tabs R-18, T-3 to T-4, and V-8.1). The mission included an administrative departure to the airspace and planned recovery back to the airfield requiring weather greater than or equal to 300 feet above ground level (AGL) and visibility greater than 1,600 meters (Tabs AA-27 to AA-28, K-5, and G-41). The planned mission execution in the airspace consisted of 12 SEAD fighters striking targets defended by simulated surface-to-air missile systems (SAMS) (Tabs R-10 and V-8.1). The 480th Lieutenant Colonel Squadron Commander (Lt Col SQ/CC) authorized the mission on an Aviation Resource Management System (ARMS) Fighter Flight Authorizations Form (Tabs AA-3 to AA-4 and V-12.1).

b. Planning

The MP arrived at the squadron at 0700L, went over operational risk management (ORM) with the "Top 3" (squadron supervision), and received a mass briefing including weather, notices to airmen (NOTAMS), an emergency procedure of the day (EPOD), and a pilot currency check (Go/No Go's) (Tabs AA-8 to AA-26, and V-2.1). The ORM for the flight was in the low risk category, and the MP satisfied all Go/No Go requirements (Tab AA-6 to AA-7 and AA-25). Afterwards, the mishap flight lead (MF1), who was also the overall mission commander, briefed the flight on specific mission execution (Tabs R-18 and V-8.1). The brief was IAW AFI 11-2F-16V3, *F-16 Operations Procedures*, dated 13 July 2016, incorporating change 1, dated 26 May 2017, paragraphs 2.8 – 2.9 (Tabs R-18 V-8.1). In between sorties, and prior to the mishap, MF1 briefed the flight regarding changes in the second sortie's execution using personal briefing guides consistent with squadron standards (Tabs R-18 and V-8.1). The briefings covered risk mitigation factors for flying in IMC and with 12 aircraft in the airspace (Tabs R-18 and V-8.1).

c. Preflight

The MP donned his flight equipment to include a helmet mounted cueing system (HMCS) capable helmet, harness, advanced technology anti-gravity suit (ATAGS), and survival vest (Tab V-11.15). Additionally, due to the exercise, the MP wore a protective combat helmet and vest and was issued an M9 handgun (Tabs T-7 and V-11.15). He carried the rest of his mission oriented protective posture (MOPP) gear to and from the MA in case of a simulated chemical attack (Tab V-11.16). The MP was assigned a different aircraft than he flew during the first sortie, so while this was the MP's second flight of the day, it was the first flight for the MA (Tab D-17). Once at the MA, the MP noticed he did not have an air combat maneuvering instrumentation (ACMI) pod, which is a device that tracks aircraft position and maneuvers (Tab V-11.8). The MP coordinated for one to be loaded on the MA, and then executed his preflight walk around (Tab V-11.8). The MP ensured his seat beacon and seat kit were set to the automatic (AUTO) position (Tab V-11.15). The MP then strapped into the ejection seat properly and secured his electronic flight book (EFB) to his leg (Tab V-11.15). The ACMI pod installation caused the MP to engine start 4 minutes late (Tab V-11.8). The MA was parked in a protective aircraft shelter (PAS) so the MP completed a GPS no track alignment (Tab V-11.14). Before taxiing, the MP ensured he took the embedded global positioning and inertial navigation set (EGI) out of "no track," which allowed the MA to make

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GPS updates, and then the MP positioned the EGI knob to navigation (NAV) mode (Tab V-11.14). During ground operations, the MP uncaged and adjusted his standby attitude indicator (SAI), checked his pilot activated recovery system (PARS), and did an instrument cockpit check prior to take-off verifying all instrumentation was working normally (Tab V-11.14). The MP did not note any significant maintenance fault lists (MFLs), pilot fault lists (PFLs), or any other malfunctions with the MA (Tab V-11.14). All other ground operations up to take-off were IAW the applicable checklist (Tab V-11.8).

d. Summary of Accident

The MF taxied on time (Tab V-11.8). When Warhawk flight got to the end of the runway (EOR), the take-off order for the exercise changed to improve airspace deconfliction (Tab V-11.8). As a result, Warhawk was the last flight to take-off instead of the first resulting in a later take-off time than scheduled (Tabs N-17 and T-4). Additionally in EOR, MF3 was unable to take-off due to a navigation instrument malfunction, so the 4-ship formation became a 3-ship formation (Tabs N-17 and V-11.8). At 1508L Warhawk flight was cleared for take-off by the tower (Tab N-17). The MP applied take-off power at 15:08:52L and was airborne at 15:09:11L (Tab J-37). At 15:09:14L, the crash survivable memory unit (CSMU) reported the landing gear handle up and the MP began attempting to take a radar lock on MF1 to fly radar assisted instrument trail formation, and flying the ground track for the PIREK 1H departure. (Tabs AA-27 to AA-28 and J-37).

Approximately 13 seconds after take-off, during the transition to IMC, the MA experienced a power disruption causing a partial electrical power loss (Tab J-25 and J-47). The MP was 304 knots calibrated airspeed (KCAS), 180 feet AGL, 8 degrees nose high, in a 5 degree left bank, heading 225 degrees, at one times the force of gravity (G), and transitioning from afterburner to military (MIL) power when the power loss occurred as depicted in *Figure 1* (Tabs J-36 and L-16). The event affected multiple essential navigation and safety systems. Specifically, the heads-up display (HUD) went blank, multifunction display sets (MFDs) turned off, the electronic horizontal situation indicator (EHSI) went blank, the EGI lost power, the PARS was unavailable, and the primary attitude director indicator (ADI) became frozen (Tab J-47). The MP saw a Master Caution Light and the modular mission computer (MMC) restart fault ("MMC RESTART") on his pilot fault list display (PFLD), and subsequently transmitted "Two is MMC restart" to the MF1 at 15:09:29L (Tabs J-37, N-3, and V-11.9).

MF1 then directed the MP to turn left, heading 150 and to climb to 6,000 feet (Tab N-3). In the turn, the MP noticed his EHSI was blank, but did not recognize his ADI was frozen (Tabs J-47 and V-11.10). The MP continued to fly what he believed was 5 to 10 degrees nose-high based upon his ADI, but was unable to determine his heading since both his HUD and EHSI were blank (Tab V-11.18). About this time, 45 seconds after takeoff, the MA descended to 280 feet above field elevation and the MP reported seeing trees at his left "11 o'clock low" through his windscreen with parameters as depicted in *Figure 2* (Tabs J-36 and R-22). The MP made an aggressive climb away from the ground and selected maximum afterburner (Tabs J-36 and V-11.10). At 15:10:07L, the MP selected the PARS button, which did not work, and called "Two is spatial D" (Tabs J-37 and N-4). MF1 then directed the MP to reference his "round dials" and use the PARS if needed (Tab N-4).

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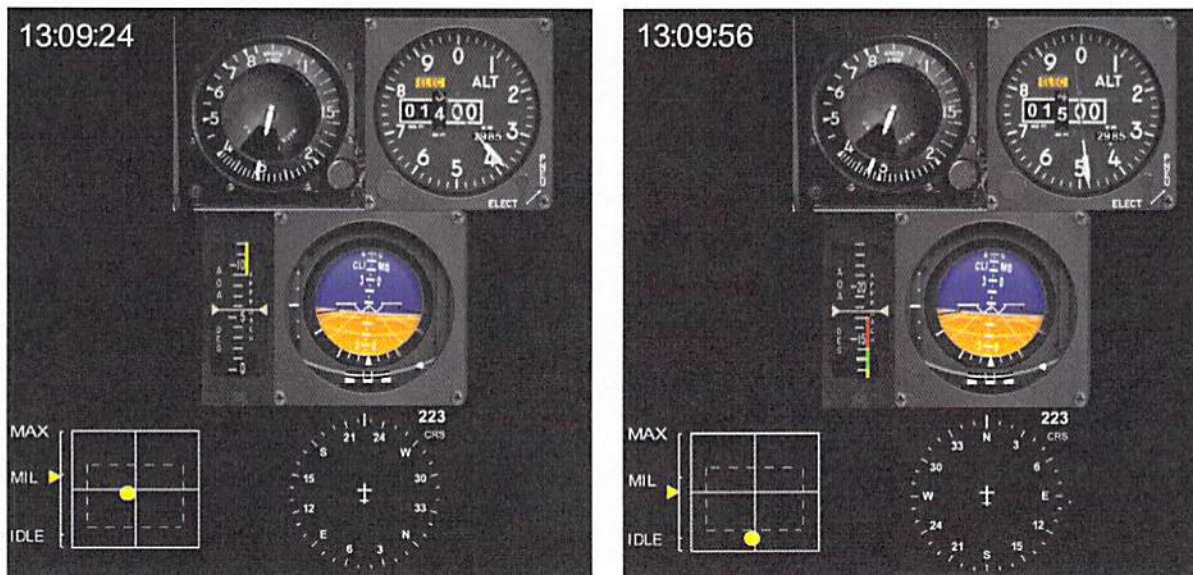


Figure 1: Parameters at Power Loss (Tab L-15) Figure 2: First Minimum Altitude (Tab L-15)

At this point, the MP realized his primary ADI was malfunctioning and not matching what he saw on the ground outside, so he began a more aggressive cross-check with his other flight instruments (Tab V-11.9 to V-11.11). Upon doing so, the MP noted his SAI showed a 60 degree right bank and slightly nose-high (Tab V-11.10). This reading did not seem to match his ADI or his perception of where he was compared to the ground (Tab V-11.11). At some point during his cross-check, the MP observed his EHSI powered back up, but was frozen and incorrectly indicating a heading of North as depicted in Figures 2 to 4 (Tab V-11.10). Additionally, his primary ADI, SAI, and EHSI were not responding as expected when he made flight control inputs (Tab R-23). While there is no information regarding the EHSI failing to north in Technical Order (TO) 1F-16CM-1, the ADI failure is consistent with warnings found the TO (Tab BB-14).

At 1 minute after take-off, the MA descended to 760 feet above field elevation with the parameters in Figure 3 (Tab J-36). The MP reported seeing trees again and initiated another aggressive wings-level climb away from the ground (Tab V-11.10). At 15:10:22L the MP attempted a PARS recovery for a second time without success due to the EGI being offline (Tab J-37, J-42 and V-11.10). As the MA climbed away from the ground, the airspeed bled off below 200 KCAS (Tab J-36 and R-23). The MP assessed if the MA were to go below the weather a third time, the MA would not have sufficient energy or airspeed to maneuver away from the ground (Tab R-23 and V-11.11). The MP made an advisory call to MF1 stating, “{inaudible}...descent, two’s ejecting,” and at 15:10:42L, 1 minute and 31 seconds after take-off, the MP commanded ejection with the parameters depicted in Figure 4 (Tab N-4 and J-37). Figure 5 uses extracted crash survivable flight data recorder (CSFDR) data to depict the MA’s altitude from take-off to the time of ejection.

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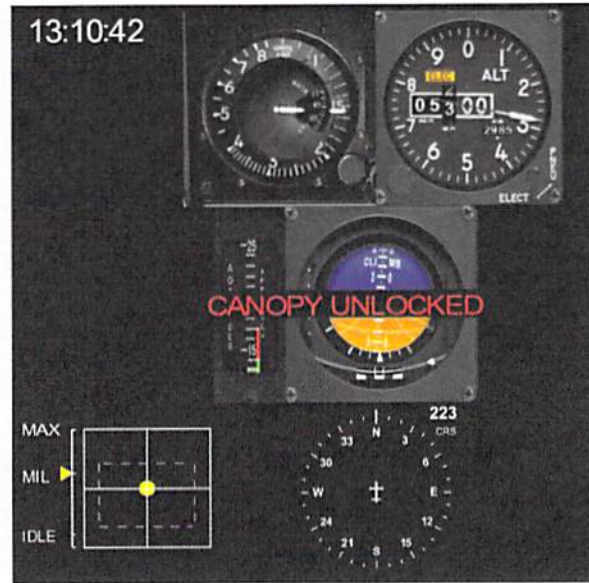


Figure 3: Second Minimum Altitude (Tab L-15) Figure 4: Parameters at Ejection (Tab L-15)

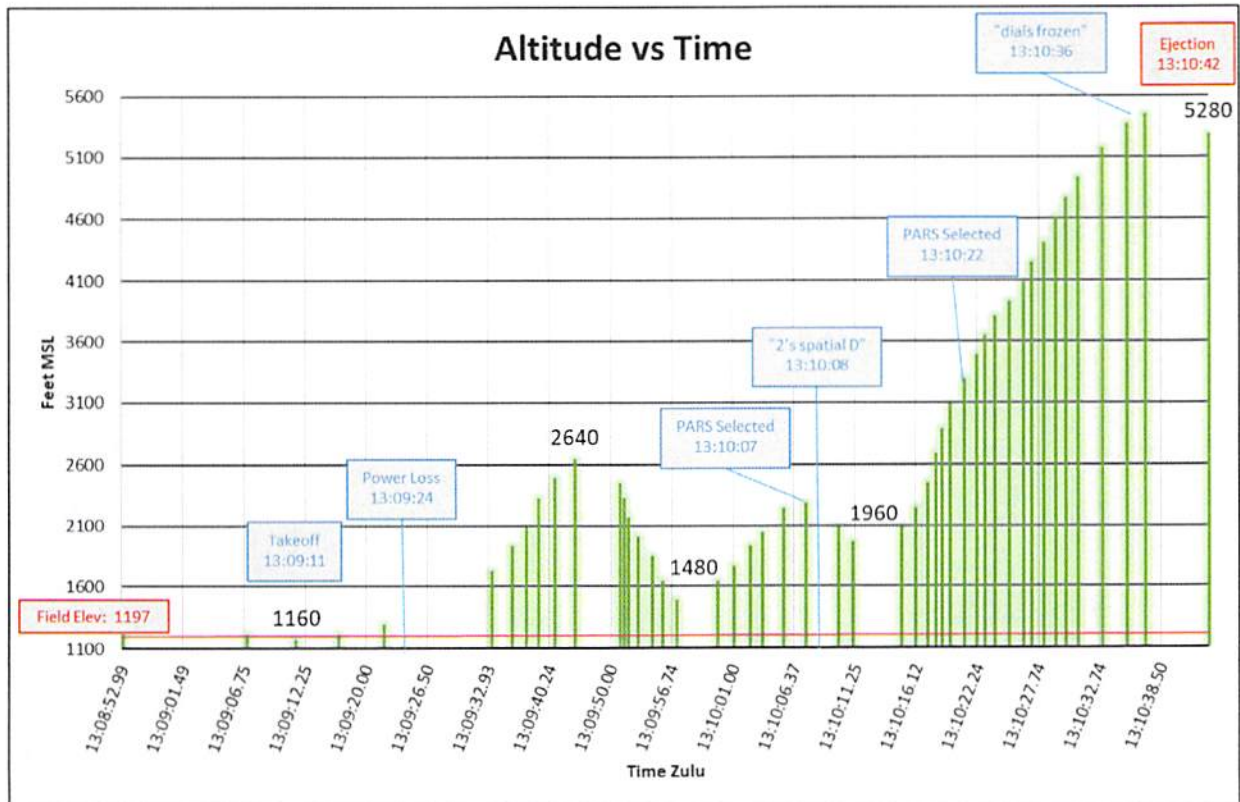


Figure 5: MA Altitude vs Time (Tabs L-16 and Z-5)

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e. Impact

The MA continued to fly for another 42 seconds, after the MP ejected, and made initial contact with the tree tops at 15:11:24.87L, 8 nautical miles south (184 degrees true) of Spangdahlem AB (Tab J-27). The MA's parameters at the time of impact were: approximately 20-25 degrees of bank, 17 degrees nose low, 550 KCAS, and heading 248 degrees true (Tab J-30). Additionally, the MA had zero control inputs and an operable engine set at MIL power (Tab J-30). Upon contact with the trees, the MA was completely destroyed and shredded into mostly small pieces leaving a debris field approximately 1,000 feet long by 300 feet wide (Tab J-27). The terrain at the crash site is dense forest with steep, rapidly rising terrain and 100 foot tall trees as depicted in *Figure 6* (Tab J-27). There was no evidence of a post-impact fire at the site (Tab J-27). The impact resulted in zero casualties or fatalities (Tab O-3).

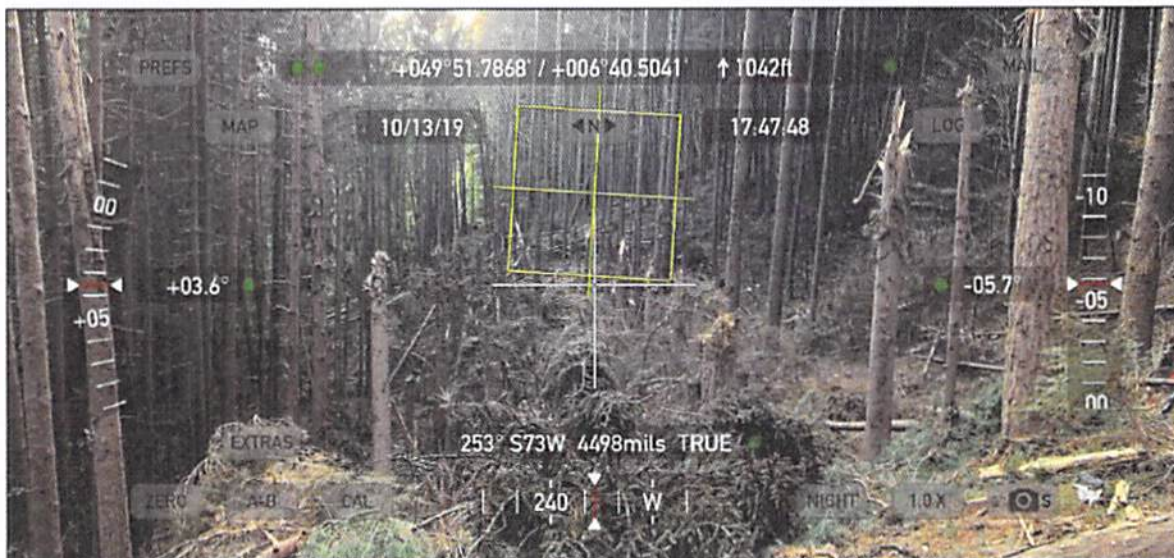


Figure 6: MA Impact Site (Tab J-27)

f. Egress and Aircrew Flight Equipment (AFE)

The MP commanded ejection by pulling the handle at 15:10:42L (Tab J-37). The MA was 152 KCAS, 5,280 feet barometric altitude or mean sea level (MSL), 19.16 degrees angle of attack (AOA), 0.81 G, 26 degrees nose high, and 4 degrees of left bank as shown in *Figure 4* (Tab L-16). These parameters are within the mode 1 operation for the advanced concept ejection seat two (ACES II) which is used for ejections with speeds less than 250+/-25 knots equivalent airspeed (KEAS) and altitudes between sea level and 15,000 feet MSL (Tab J-4). During a mode 1 ejection, the seat drogue parachute does not deploy in order to reduce time required for parachute deployment and inflation (Tab J-4). Additionally, the MA parameters at the time of ejection were within a successful ejection envelope (Tab BB-10). The canopy and ejection seat, pictured in *Figures 7* and *8*, landed 4.1 and 4.2 miles away, respectively, from the MA and the MP drifted 1.3 miles east (Tab J-3 and J-27). Analysis of the escape system shows the seat operated properly with minor defects (Tab J-13). Specifically, the minor defects consist of the hot gas hoses shearing

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instead of coming apart at the quick disconnects as designed, and the pitch control stabilization assembly (STAPAC) not rotating freely upon initiation of the ejection, which could have resulted in suboptimal pitch stabilization during the ejection (Tab J-13). The egress system was inspected within the 30-day, 12-month, and 36-month requirements (Tab D-23 to 24). The MP was current and qualified in AFE training, to include 120-day fit check, Egress, and Emergency Parachute Training (Tab G-28 to 29). The seat kit was equipped with a personnel locator beacon (PLB), but the beacon failed to activate upon man-seat separation (Tabs BB-9 and N-10). There are no other AFE issues pertinent to this investigation.



Figure 7: Ejection Seat (Tab Z-3)



Figure 8: Canopy (Tab S-5)

g. Search and Rescue (SAR)

The MA impacted a forested area at 15:11:24.97L, and at approximately the same time, a local-national eyewitness reported a jet crashing near Zemmer-Rodt, and the regional first response center began the launch of its rescue helicopter, Kristof 10 (Tabs J-27 and V-4.2). Kristof 10 is a General German Automobile Club (ADAC) helicopter based at Wittlich Hospital (Tab V-4.2). The crew consisted of a pilot, an anesthesiologist, and an emergency medical technician (Tab V-4.2). At 1511L, MF1 assumed on-scene commander duties (Tab N-6). MF1 notified the supervisor of flying (SOF) of the MP's ejection and passed an approximate bearing and radial distance from a known common reference point (BULLSEYE) (Tab N-6). MF3, still on the ground at Spangdahlem, translated the BULLSEYE location and passed latitude and longitude coordinates to the SOF at 15:14:27L (Tab N-8). Spangdahlem AB tower controllers passed these coordinates to Kristof 10 at 1522L (Tab N-19).

During the descent, the MP's parachute became entangled in the forest treetops leaving the MP suspended at an undetermined height above the ground (Tab V-11.5 to 11.6). The MP secured himself to the tree, released from his harness, and climbed down to the ground (Tab V-11.5 to 11.6). At approximately 1525L, the helicopter pilot spotted the MP's parachute, pictured in *Figure 10*, and shortly after, made visual contact with the MP who assisted the helicopter in landing with visual signals (Tab V-4.2). The rescue helicopter photographed the impact site during the rescue as shown in *Figure 9*. At 1531L, Kristof 10 landed on a nearby road and extracted the MP (Tabs

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R-24 and V-4.2). The MP was taken to Spangdahlem AB, where the helicopter landed at 1543L (Tab V-4.2). The weather was a minor factor, but the rescue helicopter remained below the low cloud deck throughout the recovery (Tab V-3.2 and V-4.2).



Figure 9: Helicopter Photo of Crash Site (Tab S-3)



Figure 10: Parachute (Tab S-29)

h. Recovery of Remains

Not applicable.

5. MAINTENANCE

a. Maintenance Documentation

The Air Force Technical Order (AFTO) 781 series of forms collectively document maintenance actions, inspections, servicing, configurations, status, and flight activities (Tab D-6 to D-30). The AFTO 781 forms, in conjunction with the Integrated Maintenance Data System (IMDS), provide a comprehensive database used to track and record maintenance actions and flight activity, and to schedule future maintenance (Tab D-43, D-68 to D-73).

A comprehensive review of the active AFTO 781 forms and IMDS revealed no discrepancies, overdue inspections, or overdue Time Compliance Technical Orders (TCTOs) that would ground the MA from flight operations (Tab D-6 to D-30, D-43, D-68 to D-73). A thorough review of the active AFTO 781 forms and IMDS historical records for the 40 days preceding the mishap revealed no recurring maintenance problems (Tabs D-6 to D-15, D-23 to D-27, D-44 to D-67, and U-5 to U-18). Additionally, the MA was operating as designed, and there was no indication of mechanical, electrical, and structural failure prior to MA take-off (Tabs D-6 to D-15, D-23 to D-27, D-44 to D-67, and U-5 to U-18).

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b. Inspections

The Pre-Flight (PR) Inspection and Basic Post-Flight (BPO) Inspection include visually examining the aircraft and operationally checking certain systems and components to ensure no serious defects or malfunctions exist. Walk-Around Inspections (WAI) are an abbreviated PR inspection and are completed as required prior to launch IAW the applicable TOs.

The total airframe operating time of the MA at takeoff of the MF was 7378.9 hours (Tab D-17 and D-20). The last PR/BPO inspection occurred on 2 October 2019 at 1500L with no discrepancies noted (Tab D-17). PR inspections were completed on 3 October 2019 at 2300L and 7 October 2019 at 2300L with no discrepancies noted on either inspection (Tab D-17). A WAI occurred on 7 October 2019 at 2300L with no discrepancies noted (Tab D-17). Prior to the mishap, the MA had no relevant reportable maintenance issues and all inspections were satisfactorily completed (Tab D-6 to D-27).

c. Maintenance Procedures

A review of the MA's active and historical AFTO 781 series forms and IMDS revealed all maintenance actions complied with standard approved maintenance procedures and TOs (Tabs D-6 to D-73 and U-5 to U-18).

d. Maintenance Personnel and Supervision

The 480th Aircraft Maintenance Unit personnel performed all required inspections, documentation, and servicing for the MA prior to flight (Tab D-6 to D-18). A detailed review of maintenance activities and documentation revealed discrepancies in the documentation of the ALQ-131 electronic countermeasure (ECM) pod adapter installation between the aircraft forms and IMDS (Tabs D-67 and U-5 to U-18). However, the noted discrepancy did not contribute in any way to the mishap. Personnel involved with the MA's preparation for flight had proper and adequate training, experience, expertise, and supervision to perform their assigned tasks (Tab DD-5).

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

Due to the nature of impact, all fluid samples were destroyed and not testable. CSMU and flight data recorder (FDR) data obtained from the MA indicated the fuel system, hydraulic system, and engine were all operating and responding to the MP's inputs prior to ejection and through time of impact (Tab L-16). A sample of hydraulic fluid recovered from the servicing cart was analyzed with no discrepancies reported (Tab D-80 to D-87). Fuel samples from the fuel storage tank and fuel truck that serviced the MA were tested with no discrepancies reported (Tab D-78 to D-79).

f. Unscheduled Maintenance

Unscheduled maintenance is any maintenance action taken that is not the result of a scheduled inspection (Tab DD-5). This is normally the result of a pilot-reported discrepancy (PRD) during flight operations or a condition discovered by ground personnel during ground operations

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(Tab DD-5). There were no unscheduled maintenance repair actions since the last scheduled inspection that would cause an issue with MA (Tab DD-5). Similarly, there were no recurring maintenance problems with the MA (Tab DD-5). There was, however, a reconfiguration on station 5 since the last inspection on the MA (Tab U-17 to U-18). Maintenance personnel installed an ALQ-131 ECM adapter and pod IAW appropriate TOs (Tab U-17 to U-18).

6. AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS

a. Structures and Systems

The MA impacted the trees 17 degrees nose low, 20-25 degrees right bank, and traveling approximately 550 knots (Tab J-30). The MA travelled approximately 1,000 feet through the forest and was completely destroyed during impact (Tab J-27). The majority of the MA was broken into pieces ranging in size from a few inches to a few feet (Tab J-27). Evidence of this is depicted in *Figure 11*. The largest debris recovered was 3 to 5 feet long (Tab J-27). The debris field was oblong in shape approximately 1,000 feet long and 300 feet wide at its widest point (Tab J-27).



Figure 11: MA Wreckage Recovered in PAS (Tab S-9)

b. Evaluation and Analysis

(1) MA Crash Survivable Flight Data Recorder (CSFDR)

The CSFDR system consists of two units. The first is the CSMU, which contains non-volatile solid-state electronic memory (Tab J-31). The CSMU contains flight data such as analog inputs, discrete inputs, and message/warning data (Tab J-31). The CSMU was recovered from the crash site (Tab J-32). The second component of the system is the Signal Acquisition Unit (SAU), which was not recovered (Tab J-31). The CSMU recorded all data required by design until 13 seconds after take-off, when it recorded multiplex (MUX) bus signals failing, and those signals returning

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8.25 seconds later (Tab J-32 to J-33). The CSFDR system operated as expected and recorded the entire flight of the MA until impact (Tab J-32).

(2) MA Digital Flight Control System (DFLCS) Data

There were no indications of degraded Flight Control System (FLCS) electrical or hydraulic power or any FLCS system failures to suggest a controllability problem occurred (Tab J-42). The FDR recorded the EGI and/or the central air data computer (CADC) "DATA BAD" value, which was caused by either low power or loss of power to the CADC and EGI or a combination or both (Tab J-42). This reported error stayed in effect the remainder of the MF (Tab J-42).

(3) MA Flight Control Surfaces

There is no data to suggest indications of degraded or inoperable flight control surfaces.

(4) MA Engine

The engine was completely destroyed on impact into the forest. There is no data to suggest an engine failure occurred (Tabs DD-5 and S-9).

(5) Hydraulic System

Based on the CSMU data both hydraulic systems were pressurized and providing hydraulic power at the time of impact (Tab L-16).

(6) Electrical System

Aircraft power is furnished internally by an alternating current (AC) power generation subsystem (Tab BB-6 and BB-29). Internal AC power is furnished by the main generator under normal conditions and the standby generator if the main generator fails (Tab BB-6 and BB-29). The emergency generator provides power if both the main and standby generator systems are unable to supply power or a failure occurs in the hydraulic system (Tab BB-6 and BB-29). External power is provided via an external power receptacle and monitor (Tab BB-6 and BB-29).

Despite a thorough search, neither the main or standby generators, nor any testable electrical components, were located in order to perform a physical analysis (Tab J-47). The CSFDR and FDR data showed there was a momentary loss or reduction in power supplied to multiple navigational components, which occurred 13 seconds after take-off; however, the data did not show a main or standby generator failure (Tab J-47 to J-48). The momentary loss or disturbance of power is considered an electrical "brownout" (Tab BB-33 to BB-36). Based on the report from Lockheed-Martin, the Senior Master Sergeant maintenance member's examination of maintenance records, TOs, and wiring diagrams, and the Senior Master Sergeant maintenance member's consultation with other SMEs, there are several potential causes for a brownout. However, given the lack of available evidence, it is not possible to determine the actual cause of the electrical power loss (Tabs DD-5 and J-47).

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(7) Escape System

The MA was equipped with an ejection seat actuated by the pilot pulling the ejection handle located on the forward part of the seat (Tab J-48). Once this occurs, the canopy separates from the aircraft and the ejection seat leaves the aircraft milliseconds later (Tab J-48). The escape system functioned as designed (Tab J-13 and J-48).

(8) MA Navigational Instruments

The MP reported the MA experienced an MMC restart by noting an “MMC RESTART” fault on the PFLD (Tab V-11.9). During the MMC restart, MP reported the HUD went blank and his MFDs turned off (Tab V-11.9). MP also stated his primary ADI froze, but did not recall the off or auxiliary flags present (Tab V-11.18). MP also reported the EHSI recycled power and then stayed on a North heading (Tab V-11.9 and V-11.18). The combination of the EHSI recycling power and showing the North heading without change and the ADI freeze indicate the EGI also lost power (Tab DD-5). The MP stated there was never any indication of a successful MMC restart in the cockpit (Tab V-11.19). The MP stated his HUD and MFDs never turned back on for the remainder of the flight (Tab V-11.19). This disruption or loss of power explains why key navigational components such as the HUD, MFDs, ADI, and EGI never returned to an operational state.

(9) Pilot Activated Recovery System (PARS)/Automatic Ground Collision Avoidance System (AGCAS)

PARS is designed to help a spatially disoriented pilot regain awareness and control of the aircraft to a safe and wings level attitude (Tabs BB-7-8 and DD-5). AGCAS is designed to reduce mishaps attributed to controlled flight into terrain (CFIT) and G-induced loss of consciousness (GLOC) (Tab DD-5). During the MF, the MP tried to activate PARS twice in an attempt to start a PARS recovery (Tabs J-35, L-16, and V-11.10 to V-11.11). CSMU and FDR data showed at 13:09:24.5 Zulu time (Z) a bit for “EGI AND/OR CADC MUX DATA BAD” was set and remained set for the remainder of the MF (Tabs J-42, L-5, and L-16). The PARS functioned correctly in that it did not return the aircraft to stable flight due to the EGI being offline (Tab BB-14).

7. WEATHER

a. Forecast Weather

On 8 October 2019, the forecast for Spangdahlem AB had winds out of the west at 8 knots, scattered clouds at 300 feet AGL, an overcast ceiling at 500 feet AGL with the top of the clouds at flight level (FL) 150, and visibility of 5,000 meters (Tab F-3). The forecast hazards included rain over the field, light turbulence from 2,000 feet to FL 180, and light rime icing from FL 080 to FL 180 (Tab F-3).

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b. Observed Weather

A meteorological aerodrome report (METAR) was generated at 1256Z (1456L) reporting winds out of the southwest at 11 knots, light rain and mist, clouds overcast at 600 feet AGL, 2,400 meters of visibility, and an altimeter setting of 29.79 inches of mercury (Tab W-13). The air traffic control tower reported the winds as 220 at 10 knots when the MF was cleared for take-off (Tab N-3). The previous flight to take-off, "Viper flight," gave a pilot report (PIREP) to the SOF at 1509L and reported the bottom of the clouds at 500 or 600 feet AGL and the tops at FL 170 (Tab N-5 to N-6). All of these observations are consistent with the forecasted weather (Tab F-3). Post-mishap weather remained unchanged (Tab V-3.2 and V-4.2).

c. Space Environment

Not Applicable.

d. Operations

The MP was operating within the prescribed weather requirements for category B pilot weather category (PWC) minimums (Tab G-41).

8. CREW QUALIFICATIONS

a. Mishap Pilot

The MP was a current and qualified combat mission ready (CMR) F-16 pilot (Tab G-40). With training dating back to 2016, the MP completed Air Force Undergraduate Pilot Training (UPT) and Introduction to Fighter Fundamentals (IFF), obtained initial qualification in the F-16, and then proceeded to his first overseas assignment at Spangdahlem AB (Tab G-33). The MP completed Mission Qualification Training (MQT) to become a certified wingman on 28 February 2018 with average progression throughout the program (Tab G-40 and G-52 to G-76). The MP flew at an inexperienced CMR rate with no probationary periods during his 21 months at Spangdahlem AB prior to the mishap (Tab G-47).

The MP was current and qualified as an inexperienced SEAD wingman (Tab G-40). In a memorandum dated 26 April 2018, the 480 Lt Col SQ/CC directed all 480 FS pilots complete supplemental IMC training with simulator events including unusual attitude recoveries and the loss of primary attitude instruments in IMC (Tab G-82). The MP completed this training on 6 May 2019 (Tab G-82). The MP was weather category B qualified, and therefore, qualified to fly instrument approaches with weather better than or equal to clouds at 300 feet AGL and visibility of 1,600 meters (Tab G-41). His total flight time was 359.5 hours, with 263.0 hours in the F-16 (Tab G-11).

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MP	Total Hours	Instrument Hours	Sorties
Last 30 Days	9.6	4.2	7
Last 60 Days	14.1	5.4	13
Last 90 Days	27.2	6.2	26

(Tab G-10)

The MP's most recent flight prior to the mishap was the first sortie the morning of 8 October 2019 where he executed a SEAD mission in support of Exercise SABER FURY (Tab T-3). He was scheduled to do the same mission type on the second sortie when the mishap occurred (Tab T-4). The mission complexity of the second sortie was less than or equal to that of the first IAW AFI 11-2F-16V3, *F-16 Operations Procedures*, dated 13 July 2016, incorporating change 1, dated 26 May 2017, paragraph 2.8.5. The MP successfully navigated to and from the airfield under similar weather conditions during the morning sortie, approximately 5 hours prior (Tab R-22).

b. Other USAF Pilots

Not applicable.

9. MEDICAL

a. MP Qualifications

At the time of the mishap, the MP was medically qualified for flying duty and required no aeromedical waivers (Tab DD-3).

b. MP Health Prior to Mishap

The MP's most recent periodic health assessment (PHA) was on 12 September 2019 (Tab DD-3). The MP had no disqualifying conditions or pre-existing medical conditions that could have affected the outcome of the mishap (Tab DD-3). When interviewed, the MP reported no recent illness that could have affected his reactions during the mishap (Tabs DD-3 and V-11.26).

c. MP Post Mishap Health and Injuries

Post-ejection, MP's heart rate was mildly elevated attributed to the ejection, subsequent descent from the tree, and rescue (Tab DD-3). MP complained of minor musculoskeletal achiness of the back and legs, consistent with the forces of ejection, the opening shock following parachute inflation, parachute landing in a tree, and descent from the tree (Tab DD-3). Exam was otherwise completely normal (Tab DD-3). There was no evidence of any serious injuries or of any conditions that could have contributed to the mishap (Tab DD-3). Additionally, x-rays and examination did not show signs of any broken bones or injury to the spine from the ejection (Tab DD-3). All musculoskeletal complaints resolved quickly, and the MP was returned to flight status and full flying duties on 17 October 2019 (Tab DD-3).

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d. Toxicology

The toxicology screen showed nothing of relevance (Tab DD-3).

e. MP Pathology

Not applicable.

f. MP Lifestyle

Based upon the interview with the MP, as well as review of the past year's medical records, the 72-hour, and the 7-day history record, there is no evidence to suggest lifestyle factors contributed to the mishap in any way (Tab DD-3).

g. MP Crew Rest and Crew Duty Time

Crew rest and crew duty time requirements are detailed in AFI 11-202V3_AFGM2019-01, *General Flight Rules*, dated 3 October 2019. Crew rest is compulsory for aircrew members prior to performing any duties involving aircraft operations and is a minimum of 12 non-duty hours before the flight duty period (FDP) begins. Crew rest is defined as free time and includes time for meals, transportation, and rest. Crew rest time must include an opportunity for at least 8 hours of uninterrupted sleep. Aircrew members are individually responsible to ensure they obtain sufficient rest during a crew rest period. The MP had more than 12 hours of crew rest prior to the mishap FDP, and also had the opportunity for at least 8 hours of uninterrupted sleep, IAW AFI requirements.

MP met crew rest and crew sleep requirements prior to the mishap (Tab DD-3). Fatigue did not affect reaction time or decision-making abilities (Tab DD-3). MP obtained 7 hours of sleep prior to the mishap, had slept continuously and well, and felt well rested the day of the mishap (Tab DD-3). In addition, during the interview the MP reported he rested, ate, and hydrated between the first sortie of the day and the MF (Tabs DD-3 and V-11.26).

h. Maintenance Personnel Rest Periods and Health Review

Medical records for the prior year, 72-hour and 7-day histories, and toxicological analysis were reviewed. Nothing was identified that could have led, or contributed to, the mishap (Tab DD-3).

10. OPERATIONS AND SUPERVISION

a. Operations

The operations tempo during a readiness exercise attempts to replicate a wartime situation with combat focused mission planning, briefings, and flight execution. As in wartime, pilots fly longer sorties and multiple times a day (Tab T-3 to T-4). The day of the mishap was the first day of the exercise (Tabs R-18, T-3, and V-8.1). The MP previously flew an exercise sortie that morning (Tab T-3). However, prior to the exercise, the MP was on leave and his last flight was 27

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September 2019 (Tab G-12 and G-19). In the month prior, the MP flew a total of seven sorties (Tab G-10 and G-19). The MP attended a mass briefing prior to the first take-off of the day and received another briefing from the MF1 between sorties (Tabs AA-8 to AA-24, R-18, and V-8.1). MF1's briefing was IAW squadron standards (Tabs R-18 and V-8.1).

b. Supervision

MF1 and the Top 3 on duty noted all members of the MF were fit to fly (Tab V-8.1). The ORM process in the squadron identified the risk for the mission to be in the "Green," or deemed low risk (Tab AA-6 to AA-7). The Top 3 approved the sortie based on their risk assessment with no other supervisory approval required (Tab V-2.1 and V-12.1). The ORM assessment worksheet recognized IMC weather as a risk and the MF1 addressed mitigation techniques for it in his preflight brief (Tabs AA-6 to AA-7 and V-8.1). The SOF and Top 3 worked with weather personnel to ensure the weather reporting was accurate and within the minimums required for all pilots planning to fly (Tab V-1.1 and V-2.1).

11. HUMAN FACTORS ANALYSIS

a. Introduction

The AIB considered all human factors as prescribed in the Department of Defense Human Factors Analysis and Classification System 7.0 (HFACS 7.0). The mishap involved physical environmental (weather, vision limitations) and technological environmental (electrical and instrumentation failures) factors as well as sensory misperception factors that cumulatively manifested as pilot-recognized spatial disorientation (SD). Relevant factors are discussed below.

b. PE101 Environmental Conditions Affecting Vision

HFACS Code PE100, Physical Environment, refers to factors such as weather, climate, fog, brownout (dust or sandstorm) or whiteout (snowstorm) that affect the actions of the individual. Furthermore, HFACS Code PE101, Environmental Conditions Affecting Vision, is a factor that includes obscured windows; weather, fog, haze, darkness; smoke, etc.; brownout/whiteout (dust, snow, water, ash or other particulates); or when exposure to windblast affects the individual's ability to perform required duties.

The weather on 8 October 2019 for the time-period of the flight was scattered clouds at 300 feet and overcast at 500 feet, requiring instrument flight (Tab F-3). When a pilot has a wide, clear view, vision is a dominant input, overriding all other sensory input in importance. When visual contact with the horizon is lost, the vestibular system becomes unreliable, and can result in sensory illusions unless overridden by another visual cue from instrument information (Tab BB-40). The absence of visual cues while flying, like the conditions encountered during the MF, makes reliance on instrumentation absolute, to override the inherent, normal sensory illusions of motion, orientation, and acceleration.

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c. PE202 Instrumentation and Warning System Issues

HFACS Code PE202, Instrumentation and Warning System Issues, is a factor when instrument factors such as design, reliability, lighting, location, symbology, size, display systems, auditory or tactile situational awareness or warning systems create an unsafe situation.

The MP reported the lighting in his cockpit was adequate (Tab V-11.30). From recovered CSFDR data and the interview, the MP experienced the loss of primary flight and navigation systems without corresponding fault or failure indications (Tab V-11.18). From the available data, and his interview, it is clear the primary ADI froze in a slightly nose-high climbing attitude, even though his actual flight path at the time was a descending left bank turn. Because there were no OFF or auxiliary (AUX) flags on the primary ADI warning him that his instruments were wrong, he was only able to determine his aircraft attitude from a momentary glimpse of the trees as he descended out of the clouds. Multiple attempts to cross-check between the primary and SAI were also unable to resolve the mismatch between visual and instrument based cues and discern proper aircraft orientation.

d. PC508 Spatial Disorientation (SD)

HFACS Code PC500, Sensory Misperception, refers to multiple factors resulting in degraded sensory inputs (visual, auditory or vestibular) that create a misperception of an object, threat, or situation. Specifically, PC508, Spatial Disorientation (SD), is a factor when an individual fails to correctly sense a position, motion, or attitude of the aircraft/vehicle/vessel or of oneself. SD may be unrecognized and/or result in partial or total incapacitation.

Multiple components of PC500, Sensory Misperception, contribute to PC508, Spatial Disorientation. As discussed below, loss of instruments, i.e. loss of key navigational components used to build a pilot's internal (cerebral, trained) self-generated construct of his location in air and space relative to the Earth, make a pilot susceptible to erroneous perceptions of orientation, motion, or acceleration as per PC501, Motion Illusion-Kinesthetic, PC502, Turning/Balance Illusion-Vestibular, which manifest as PC508, Spatial Disorientation.

The body uses three integrated systems that work together to ascertain orientation and movement in space. Vestibular system—organs found in the inner ear that sense position by the way we are balanced. Somatosensory system—nerves in the skin, muscles, and joints that, along with hearing, sense position based on gravity, feeling, and sound. Visual system—eyes, which sense position based on what is seen. While all three systems work together, the visual system is dominant, if available, either in actual visual conditions or as a visual construct built from instrument information. Without visual references outside the aircraft, there are many situations in which combinations of normal motions and forces create convincing illusions (Tab BB-40). If visual cues are compromised, by darkness or weather, normal motion can be misinterpreted as illusions; however, the pilot usually avoids this by using aircraft instruments for orientation. If the pilot loses the instruments, then they lose the visual information necessary to build the visual-dominant, artificially generated three-dimensional orientation construct in space.

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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) AFI 11-2F-16V3, *F-16 Operations Procedures*, dated 13 July 2016, incorporating change 1, dated 26 May 2017
- (3) AFI 11-202V3_AFGM2019-01, *General Flight Rules*, dated 3 October 2019
- (4) Department of Defense Human Factors Analysis and Classification System 7.0 (DoD HFACS 7.0), available at: <https://www.safety.af.mil/Divisions/Human-Factors-Division/HFACS/>
- (5) Federal Aviation Administration, *Pilot's Handbook of Aeronautical Knowledge*, FAA, H-8083-25B, 2016, available at: https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/phak/

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

14 January 2020

STRATTON.JOHN, Digitally signed by
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JOHN C. STRATTON, Colonel, USAF
President, Accident Investigation Board

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STATEMENT OF OPINION

F-16CJ, T/N 91-0340

**480TH FIGHTER SQUADRON
52D FIGHTER WING
SPANGDAHLEM AIR BASE, GERMANY**

Under 10 U.S.C. § 2254(d) the opinion of the accident investigator as to the cause of, or the factors contributing to, the accident set forth in the accident investigation report, if any, may not be considered as evidence in any civil or criminal proceeding arising from the accident, nor may such information be considered an admission of liability of the United States or by any person referred to in those conclusions or statements.

1. OPINION SUMMARY

This Accident Investigation Board was conducted IAW Air Force Instruction 51-307.

On 8 October 2019, the mishap pilot (MP), flying a F-16CJ, tail number (T/N) 91-0340, assigned to the 480th Fighter Squadron, "the Warhawks," 52d Fighter Wing, Spangdahlem Air Base (AB), Germany, conducted a routine training sortie as part of the wing's local readiness Exercise SABER FURY. Shortly after take-off, at 15:10:42 hours local (L) time, the MP successfully ejected from the mishap aircraft (MA) with minor injuries. At 15:11:24L, the MA was destroyed upon impact in a forested area 8 nautical miles (nm) south of the base.

The mishap flight was planned and authorized as a suppression of enemy air defense (SEAD) training mission within the local training airspace. The MP was flying as number two of a scheduled 4-ship formation, but departed as a 3-ship. The prevailing weather at the airfield, and in the surrounding area, was a ceiling at 500 feet with instrument meteorological conditions (IMC) up to 15,000 feet. Approximately 13 seconds after take-off, during the transition to IMC, the MA experienced a power disruption causing a partial electrical power loss (also known as an electrical "brownout") which failed the MP's primary flight and navigation instruments without corresponding fault or failure indications. This power disruption also caused the embedded global positioning and inertial navigation set (EGI) to lose power and remain off-line. The subsequent degradation and mismatch in data between the primary and standby instruments caused the pilot to become spatially disoriented at low altitude and in IMC. After two failed attempts to activate the pilot activated recovery system (PARS), following two instances of visually acquiring trees below the 500-foot ceiling, the MP successfully egressed the aircraft.

The MP was an F-16CJ combat mission ready (CMR) wingman with 359.5 total flying hours, and 263.0 F-16 hours. The MP was current and qualified for all elements of the mission to be flown. This was the MP's second flight of the day and the MP was the sole pilot of the MA. The mishap

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resulted in zero military or civilian casualties and the loss of a \$25,551,000.00 United States government asset.

I find, by a preponderance of the evidence, the cause of the mishap was the combination of two factors. First, the MA experienced a partial electrical power loss (brownout). The power loss caused a cascading failure of the EGI and the MP's primary flight and navigation instruments. Due to the EGI's loss of power, the primary attitude direction indicator (ADI) continued to display unreliable data without fault or failure indications and prevented the MP from transitioning fully to the standby attitude indicator (SAI) for attitude reference. Second, the weather conditions at the time of the power disruption caused the MP to rely on his primary and standby flight instruments to maintain aircraft control during a critical phase of flight. The mismatch in data provided by the primary and standby attitude indicators, due to the power disruption, caused the MP to become spatially disoriented and unable to maintain aircraft control in the weather and at low altitude. The absence of either factor may have prevented this mishap.

I developed my opinion by carefully considering the standard of proof for the preponderance of evidence and the requirements for causes and substantially contributing factors. I analyzed available flight data, the Lockheed Martin (LM) crash report, the mishap animation, witness testimony, engineering analysis, Air Force technical orders, and other information provided by technical and subject matter experts (SMEs). The MA's crash survivable memory unit (CSMU), which houses non-volatile solid-state electronic memory data and the maintenance fault list (MFL) recorded during flight, was recovered from the crash site.

2. CAUSE

a. Electrical Power Disruption

The data gathered from the CSMU provides definitive evidence of a power disruption in the MA approximately 13 seconds after take-off. However, the total destruction of the aircraft significantly limited the ability to analyze physical evidence, and therefore, I could not determine the cause of the power disruption. While the cause of the electrical malfunction is inconclusive, the power disruption caused a partial electrical power loss to the MP in the cockpit. At the time the CSMU recorded the faults indicating the power disruption, the MP observed the following indications:

1. Master Caution Light – On
 - a. Corresponding AVIONICS FAULT light on caution panel - unobserved
2. Pilot Fault List (PFL) displayed on Pilot Fault List Display (PFLD) – MMC Restart
3. Head's Up Display (HUD) – Blank
4. Multifunction Display System (MFDs) – Off
5. Primary Attitude Direction Indicator (ADI) – No OFF or AUX warning flags observed
6. Electronic Horizontal Situation Indicator (EHSI) – Blank
7. Primary Airspeed Indicator – Normal or unobserved
8. Primary Altitude Indicator – Normal or unobserved
9. Standby Attitude Indicator (SAI) – Normal or unobserved
10. Engine Instruments – Normal or unobserved

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Based on cockpit indications, the MP analyzed the situation as an MMC restart and transmitted "Two is MMC Restart" on the inter-flight radio at 15:09:29L. During a normal MMC restart, the primary ADI and EGI should function normally. However, the power disruption affected more than just the MMC as the MP observed the ESHI and MFDs also going blank. LM analysis concluded the EGI did not recover from the partial electric failure and remained offline for the remainder of the flight. The EGI remaining offline rendered the PARS unavailable both times the MP attempted to activate the system. Additionally, the EGI remaining offline caused the EHSI and the primary ADI to freeze or provide unreliable data. While there is no information regarding the EHSI failing to north in Technical Order (TO) 1F-16CM-1, the ADI failure is consistent with warnings found in the TO.

The partial electrical power loss led to the failure of the MP's primary flight and navigation instruments without corresponding fault or failure indications and was causal in this mishap.

b. Weather Conditions

The weather condition at the time of the mishap was a ceiling at 500 feet with solid clouds up to 15,000 feet. At the time of the electrical power loss, the MP was transitioning to IMC, attempting to take a radar lock on the mishap flight lead (MF1) to fly radar assisted instrument trail formation, and flying the ground track for the PIREK 1H departure. After the MP transmitted "Two is MMC Restart," MF1 responded with "Copy, turn left heading 1-5-0 climb to six thousand, one's in a left turn 1-5-0 climbing to seven, flight level 0-7-0." The MP initiated a left turn from a heading of 225 toward a heading of 150 in accordance with the flight lead's direction and the published departure procedure. During the MP's turn to heading 150 without an operable ADI or EHSI, the MA began to lose altitude and the MP saw trees coming into view at the 11 o'clock position through his HUD and windscreen.

The visual confirmation of the ground set in motion a sequence of the MP attempting to determine which instruments were reading correctly and which were not. At the same time, the MP recognized he was spatially disoriented. That is to say, he recognized the scenario and conditions for spatial disorientation to occur and recognized a mismatch and conflict between his sensory inputs and the instruments available to him. The MP can only realize this when provided with other information that negates the ADI information. In this case, it was a momentary glimpse of trees providing a visual cue the ADI information he was trusting was inadequate or incorrect. After the first recovery due to seeing the ground, the MP correctly attempted to activate the PARS at 15:10:07L and transmitted "Two is spatial D" on the radio at 15:10:08L.

The MP also began to make deliberate flight control inputs to detect trends on his airspeed and altitude gauges, as well as his primary ADI and SAI, to determine which instruments were providing accurate data. While trying to make sense of the instruments for approximately 10-15 seconds, the MA again descended below the clouds (500' ceiling) where the MP saw the trees for the second time. The MP again initiated another roll to wings level and pull away from the ground while selecting the PARS for a second time at 15:10:22L. The PARS functioned correctly in that it did not return the aircraft to stable flight due to the EGI being offline. Now in a nose high attitude and climbing away from the ground, the MP transmitted "[inaudible]...dials are frozen"

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at 15:10:36L and then made his final radio call of “[inaudible]...descent, two’s ejecting” at 15:10:39L.

The MP overcame several human factors while attempting to maintain aircraft control and determine which instruments were providing accurate information. The MP recognized he was spatially disoriented, transmitted his condition to his flight lead, and tried to resolve it using his instruments. While the ADI and EHSI continued to display unreliable information without corresponding fault or failure indications, the MP correctly initiated his automatic recovery system multiple times and induced specific flight control inputs to detect trend information with the altimeter and airspeed indicators to determine which attitude display was correct. However, without an outside visual reference due to IMC conditions, the MP could not resolve the mismatch in data provided by the primary and standby attitude indicators.

The weather denied the MP’s ability to gain an accurate visual reference to confirm the MA orientation and flight profile at low altitude and was causal in this mishap.

3. SUBSTANTIALLY CONTRIBUTING FACTORS

I did not find any act, omission, condition, or circumstance that played an important role, directly or indirectly, where its correction, elimination, or avoidance would not, by itself, have prevented the mishap.

4. CONCLUSION

I find, by a preponderance of the evidence, the cause of the mishap was the combination of two factors. First, the MA experienced a partial electrical power loss (brownout). The power loss caused a cascading failure of the EGI and the MP’s primary flight and navigation instruments. Due to the EGI’s loss of power, the primary attitude direction indicator continued to display unreliable data without fault or failure indications and prevented the MP from transitioning fully to the standby attitude indicator for attitude reference. Second, the weather conditions at the time of the power disruption caused the MP to rely on his primary and standby flight instruments to maintain aircraft control during a critical phase of flight. The mismatch in data provided by the primary and standby attitude indicators, due to the power disruption, caused the MP to become spatially disoriented and unable to maintain aircraft control in the weather and at low altitude. I did not find the MP to be causal, nor did I find any other factors that substantially contributed to the mishap.

14 January 2020

STRATTON.JOH Digitally signed by
STRATTON.JOHN.C.1153489897
Date: 2020.01.14 12:24:19 Z
N.C.1153489897
JOHN C. STRATTON, Colonel, USAF
President, Accident Investigation Board