

UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION
BOARD REPORT



F-16C, T/N 87-0296
100TH FIGHTER SQUADRON
187TH FIGHTER WING
DANNELLY FIELD, AL



LOCATION: OSHKOSH, WI
DATE OF ACCIDENT: 28 JULY 2011
BOARD PRESIDENT: COL MICHAEL R. KELLEY
CONDUCTED IAW AIR FORCE INSTRUCTION 51-503

EXECUTIVE SUMMARY

AIRCRAFT ACCIDENT INVESTIGATION

**F-16C, T/N 87-0296
Dannelly Field, Alabama
28 July 2011**

On 28 July 2011, at approximately 1120 hours local time (L), an F-16C, tail number 87-0296, assigned to the 100th Fighter Squadron, 187th Fighter Wing, Dannelly Field, Alabama departed the prepared runway surface of Wittman Regional Airport (KOSH) causing \$5.4 million damage to the mishap aircraft (MA). The mishap pilot (MP) egressed the aircraft unharmed; there was only minor damage to Wittman Regional Airport.

The MP was number two of a two-ship formation on a continuation training (CT) mission to the AirVenture 2011 air show at KOSH. After an uneventful flight from Alabama to KOSH, the flight entered the airport landing pattern. During the MP's landing roll, the MA's environmental control system (ECS) caused extreme fogging that completely obscured the MP's visual cues and severely affected the correct execution of his normal landing procedures. The MP correctly applied the defog procedure without effect, resulting in the MA running off the end of the airport's 8002 ft runway.

The weather at the field was 1400 broken, 6 miles visibility, and calm winds. The weather forced the mishap flight (MF) to fly a lower than normal overhead pattern resulting in a flat final turn. The MA landed above computed touchdown speed with the speedbrakes closed. The MP attempted to aerobrake, but could not gauge the angle of attack (AOA) because of ECS fog. The MA never achieved the desired aerodynamic braking resulting in the jet exiting the prepared surface coming to rest approximately 300 ft into the grass infield. The MP egressed and emergency vehicles responded.

The board president found by clear and convincing evidence that the cause of the mishap was extreme fogging in the MA cockpit, caused by the MA ECS, that completely obscured the MP's vision. The board president found by a preponderance of the evidence that substantially contributing factors were an inadequate aerobrake, a fast touchdown speed, and closed speedbrakes. Aerodynamic braking provides the most effective braking in the F-16 during landing. The ECS fog denied the MP the ability to establish a proper aerobrake increasing his landing distance. The fast touchdown speed increased the landing distance, but would have been negated by a proper aerobrake. Speedbrakes would add some minor aerodynamic drag during the landing roll, but would not have prevented the MA's runway departure. The speedbrakes' primary purpose is to increase drag which at landing airspeeds provides for a higher power setting allowing for faster engine spool up in the event of go around. If not for the lack of visual and instrument references, the MP could have executed a proper aerobrake, come to a complete stop on the runway, and still had approximately 1000 ft of runway remaining.

Under 10 U.S.C. 2254(d), any opinion of the accident investigators as to the cause of, or the factors contributing to, the accident set forth in the accident investigation report, 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.

SUMMARY OF FACTS AND STATEMENT OF OPINION
F-16C, T/N 87-0296
28 JULY 2011

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COMMONLY USED ACRONYMS AND ABBREVIATIONS

187 FW	187 th Fighter Wing	KIAS	Knots Indicated Airspeed
AF	Air Force	cts	Knots
AFB	Air Force Base	L	Local
AFE	Aircrew Flight Equipment	LM-Aero	Lockheed Martin Aeronautics Company
AFI	Air Force Instruction	Lt Col	Lieutenant Colonel
AFPAM	Air Force Pamphlet	M	Mach
AGL	Above Ground Level	MA	Mishap Aircraft
AIB	Aircraft Investigation Board	Maj	Major
BPO/PR	Basic Post-Flight / Pre-Flight	MAJCOM	Major Command
Capt	Captain	MFL	Mishap Flight Lead
CAUT	Caution	MOA	Military Operating Area
Col	Colonel	MP	Mishap Pilot
CSFDR	Crash Survivable Flight Data Recorder	MS	Mishap Sortie
CFPS	Combat Flight Planning Software	MSL	Mean Sea Level
DoD	Department of Defense	NM	Nautical Miles
EAA	Experimental Aircraft Association	NOTAM	Notices to Airmen
ECS	Environmental Control System	OG	Operations Group
EPU	Emergency Power Unit	Ops Tempo	Operations Tempo
FL	Flight Lead	ORM	Operational Risk Management
FLCS	Flight Control System	OSS	Operation Support Squadron
FPM	Feet Per Minute	PA	Public Affairs
FS	Fighter Squadron	PSI	Pounds Per Square Inch
ft	Feet	RTB	Return-To-Base
g	Gravitational Force	SADL	Situational Awareness Data Link
HUD	Heads up Display	SAR	Search and Rescue
IAW	In Accordance With	SII	Special Interest Item
IFR	Instrument Flight Rules	sm	Statute Miles
IMDS	Integrated Maintenance Data System	SOF	Supervisor of Flying
IP	Instructor Pilot	TCTO	Time Compliance Technical Order
JOAP	Joint Oil Analysis Program	T/N	Tail Number
K	Thousand	TOD	Tech Order Data
KCAS	Knots Calibrated Airspeed	TOLD	Takeoff and Landing Data
KOSH	Wittman Regional Airport	UFC	Up Front Control
KMGH	Montgomery/Dannelly Field	VFR	Visual Flight Rules
KTAS	Knots True Airspeed	VVI	Vertical Velocity Indication

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

SUMMARY OF FACTS

1. AUTHORITY AND PURPOSE

a. Authority

On 1 September 2011, Brigadier General Christopher F. Burne, on behalf of the Air Combat Command Commander, appointed the Board President to conduct an aircraft accident investigation of the 28 July 2011 crash of an F-16C aircraft, tail number 87-0296, at Oshkosh, WI. The investigation was at Dannelly Field, AL, from 8 September 2011 through 28 September 2011. A Pilot Member, Legal Advisor, Medical Member, Maintenance Member, and Recorder were also appointed (Tab Y-3).

b. Purpose

This is a legal investigation convened to inquire into the facts surrounding the aircraft or aerospace accident, to prepare a publicly-releasable report, and to gather and preserve all available evidence for use in litigation, claims, disciplinary actions, administrative proceedings, and for other purposes.

2. ACCIDENT SUMMARY

F-16C, S/N 87-0296 departed the prepared runway surface of Wittman Regional Airport (KOSH) during landing at the AirVenture 2011 air show. As the aircraft entered the soft soil, the nose wheel broke off and the intake contacted the ground breaking off the nose section as the aircraft came to a stop. The pilot egressed unharmed. The aircraft sustained severe damage, estimated at \$5.4 million (Tab P-5). There was only minor damage to Wittman Regional Airport infield. Media interest was generally low; however, hundreds of spectators witnessed the mishap.

3. BACKGROUND

The 187th Fighter Wing, stationed at Dannelly Field, AL, maintains an F-16 fighter wing. The 100th Fighter Wing Squadron is a component of the 187th Fighter Wing. The wing and its subordinate units are all components of the Air Force's Air Combat Command (Tab CC- 6 – 19).

a. MAJCOM

Air Combat Command's (ACC) primary mission is to provide combat airpower to America's warfighting commands. ACC operates fighter, bomber, reconnaissance, battle-management, and electronic-combat aircraft and also provides command, control, communications and intelligence

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systems, and conducts global information operations. As a force provider, ACC organizes, trains, equips and maintains combat-ready forces for rapid deployment and employment (Tab CC-6 – 9).

b. Unit Information

(1) NAF

Ninth Air Force controls ACC fighter forces based on the East Coast of the United States and is responsible for overseeing the management of six wings and three direct reporting units, as well as ensuring the operational readiness of 14 designated units of the Air National Guard and Air Force Reserve (Tab CC-10 – 15).



(2) Wing

The 187th Fighter Wing is located in Montgomery, Alabama and is the home of a squadron of F-16C Fighting Falcon Aircraft. The unit has received numerous Flight Safety awards from the Air Force Air Combat Command and the Air National Guard for its safety record. The Wing has also been recognized by ACC and the 9th Air Force Inspector General for excellence during Operational Readiness Inspections and Unit Compliance Inspections over the last two decades (Tab CC-16 – 17).



(3) Squadron

In 2007, the 187th Fighter Wing of the Alabama Air National Guard deactivated its 160th Fighter Squadron and reactivated it as the 100th Fighter Squadron in honor of the Tuskegee Airmen (Tab CC-18 – 19).



c. Aircraft

The F-16 Fighting Falcon is a compact, highly maneuverable, multirole fighter aircraft that has been proven in air-to-air combat and air-to-surface attack. Since Sept. 11, 2001, the F-16 has been a major component of the combat forces committed to the Global War on Terrorism (Tab CC-3 – 5).

4. SEQUENCE OF EVENTS

a. Mission

The mishap sortie (MS) was scheduled as a 2-ship cross-country flight in support of a Tuskegee Airman event during the annual Experimental Aircraft Association (EAA) AirVenture Oshkosh 2011 air show (Tab CC-20 – 22) on 28 July 2011. The two aircraft in the MS were piloted by the Mishap Flight lead (MFL) and the Mishap Pilot (MP), with the MP as the wingman (Tab K-

9). The MS was approved by the Secretary of the Air Force for Public Affairs (SAF/PA) and the Alabama National Guard Adjutant General (NGAL/TAG) (Tab HH-3 – 5).

b. Planning

The MFL planned the MS the day prior on 27 July 2011 (Tab V-2.3). Forecasted weather indicated conditions would be suitable for a visual arrival (Tab V-1.7). The MFL planned the mission using Combat Flight Planning System (CFPS) software to compute and print necessary mission materials (takeoff and landing data (TOLD) and lineup cards with fuel computation) (Tab K-5). The MFL filled out DD Form 175 Flight Plan form (Tab K-3), copied a frequency table from the AirVenture NOTAM (Tab K-7), highlighted the planned route and frequencies on IFR Enroute High Altitude chart (Tab V-2.3), and secured a Chicago Sectional chart for VFR operations not normally carried in the cockpit (Tab GG-3). The MFL briefed all the elements of the mission planning process (Tab V-1.7, V-2.3). The MFL discussed the landing distance, the high visibility of landing at KOSH during the air show and alternate airport considerations (Tab V-1.7, 2.5). The MP and MFL reviewed the AirVenture NOTAM (Tabs V-1.7, V-2.3, K-14) for the turbine/warbird arrival procedures and discussed plans to coordinate a deviation of the procedure to hold south of the airfield in order to deconflict from civilian warbird traffic (Tab K-31).

On the day of the mishap both the MP and MFL arrived at the squadron at 0715L (Tab V-1.3). The MP went to his office to check e-mail while the MFL checked the weather, NOTAMs, and filed the DD-175 flight plan (Tab V-1.3). The final brief was conducted in the MP's office using the 100th Fighter Squadron In-flight Guide (IFG), General Briefing Guide (Tab V-1.8). The MFL briefed that the forecast weather was VFR for the arrival time although the observation was currently IFR for low visibility and clouds (Tab V-2.4). The NOTAMs, FCIF's and SII's were briefed (Tab V-1.3). The MP tasked the MFL to call the KOSH tower in order to coordinate the planned deviation to the arrival procedure and on any time slot requirements (Tab V-1.3). The MFL and the MP also discussed parking concerns after landing (Tab V-1.8). The MFL outlined a tactical training objective during the flight to practice Air-to-Air targeting communication (Tab V-1.8). The MP stated, "For a cross-country brief, I thought he was very, very thorough" (Tab V-1.8). Mission planning was accomplished according to standard procedures.

c. Preflight

The MFL and MP dressed with appropriate Aircrew Flight Equipment (AFE) and received a step brief from the Supervisor of Flying (SOF) (Tab V-1.3, V-2.4). The SOF discussed the current and forecasted weather for KOSH and agreed on expected VFR conditions at arrival time. Both the MFL and MP stepped to their assigned aircraft (Tab V-1.3, V-2.4), reviewed maintenance forms, (Tab D-6) and conducted an exterior inspection of their aircraft. The interior inspection, starting, and after start procedures were uneventful. The MP stated that the Environmental Control System (ECS) operated normally with one adjustment to the DEFOG lever to decrease wispy fog emanating from ECS ducts (Tabs V-1.10, BB-11). No further adjustments were required of the DEFOG lever until the MA landing roll (Tab V-1.11). After start, the MFL

stepped to the spare aircraft because of UHF radio issues delaying taxi and the planned takeoff of 0930L (1430Z) (Tab V-1.3).

d. Summary of Accident

The MP took off from Montgomery/Dannelly Field (KMGM) approximately 0950L and proceeded to rejoin with the MFL into line-a-breast tactical formation while climbing to 28,000 ft (Tab V-1.3). The departure and enroute portions of the sortie were uneventful (Tab V-2.3). During the descent, the MFL reformed the formation to 1-2 mile data link trail while descending into instrument meteorological conditions (IMC) (Tab V-1.4, V-2.3). Milwaukee Approach Control descended the flight via radar vectors to the runway 36L ILS final approach course (Tab V-1.4, V-2.3).

During the final descent, the flight flew into visual meteorological conditions (VMC) and obtained visual contact with the KOSH airfield (Tab V-1.4, V-2.3). On initial contact with the control tower, the field was reported VFR (Visual Flight Rules) with ceiling 1,400 ft broken (Tab N-5). The MFL requested and was cleared by KOSH tower direct to the overhead pattern for a low approach and subsequent closed overhead traffic patterns (Tab N-5). The MP followed the MFL in trail to initial runway 36L (Tabs N-5, V-1.4, V-2.3).

On the downwind leg, a scattered layer of clouds drove a lower than expected pattern altitude which lead to overshooting final turns by both MFL and MP (V-1.4, V-2.6). The flight executed low approaches and a closed overhead pattern onto downwind for a second low approach (Tabs N-5, V-2.6). The second downwind leg was flown wider, but still resulted in slightly overshooting final turns (Tab V-1.14).

Based on the weather the MFL informed the tower that the next landing would be a full-stop, and the MFL landed uneventfully and cleared the runway at taxiway A-1 (Tabs O-26, V-1.4).

Crash Survivable Flight Data Recorder (CSFDR) and photographic evidence shows the fuel weight of 2,850 lbs and a total MA weight of 24,500 lbs at landing (Tab S-19, K-53, Tab L-attachment C). CFPS computed approach and landing speeds for the MA were 151 and 140 knots respectively (Tab GG).

The MP lowered the landing gear and commenced the final turn. The final turn was slightly overshooting and slow, requiring the MP to increase power and adjust his flight path (Tab V-1.14). Speedbrakes were not used during the landing rollout (Tab S-16, S-35 – 38). This is not IAW normal procedures (TAB BB-6). The AIB was unable to ascertain if they were never opened or if they were closed during the final turn while the MP adjusted airspeed.

The MP landed at 1120L touching down just past the 1,000 ft runway marker which was confirmed by witness testimony and photographic analysis (Tab V-1.14, GG-3 – 4). The AIB estimates the touchdown was approximately 1000-1300 down runway 36L and at approximately 165-175 knots with the speedbrakes closed (Tab S-35—38, DD-26, GG-3).

Cockpit ECS fog started developing in the MA as it approached the flare. As the throttle was retarded to idle, fog began to envelope the entire cockpit (Tab V-1.5, Z-13). As the MP began to set a pitch attitude for the aerobrake passing through 10-11 degrees, he lost sight of the HUD gun-cross and was unable to use the Nose Wheel Steering (NWS) indicator and AOA indexers for a visual reference (Tab V-1.5, V-1.12). CSFDR data indicates that the aerobrake varied between 5 and 11-degrees AOA during the rollout (Tab DD-26 – 28). The MP started losing forward visibility first (Tab V-1.5). Using the view out the side of the canopy, the MP focused on keeping the aircraft tracking down the runway (Tab V-1.5). The MP reached for the DEFOG lever and shoved it full forward (Tab V-1.5, 1.12). He held it in that position for one or two seconds with no effect and then recycled, with yet again no change in ECS fog or airflow (Tab V-1.5, 1.12). The MP then experienced brief vertigo, almost a tumbling sensation, and considered ejection but was concerned for spectators and aircraft along the runways (Tab V-1.5). The MP did not consider initiating a go-around because of the disorientation and no assurance that the ECS fog would dissipate, rendering the MP blind while navigating through the congested traffic pattern (Tab V-1.15).



The MP momentarily read 140 knots on the MA airspeed indicator during the rollout and thought he had enough runway, but could not see any runway remaining markers (Tab V-1.12). The MP then applied main landing gear wheel brakes and the nose came down from the aerobrake (Tab V-1.15). The MP felt the brake anti-skid system cycle and continued to brake as hard as he could (Tab V-1.12). The MP never saw the end of the runway approaching, but felt that he had enough remaining runway to stop (Tab V-1.5). Runway 36L has no overrun or arresting gear (Tab O-26). As the MA departed the runway surface, the MP felt a bump and rumbling, and then the nose dug in (Tab V-1.6). The ECS fog cleared as the engine ingested dirt and sod (Tab V-1.6). After the MA came to a stop, the MP raised the canopy and egressed over the left canopy rail jogging northwest away from the MA.

e. Impact

Aircraft S/N 87-0296 departed KOSH runway 36L at approximately 1120L (1620Z) on 28 July 2011, at approximately 80 knots and 25 ft left of runway centerline (Tab S-57, DD-28). As it entered the soft soil, the nose wheel turned and broke off (Tab S-42). The nose contacted the ground, breaking off both the nose and avionics bay, just forward of the cockpit bulkhead (Tab S-46—51). The engine intake ingested dirt and sod as the aircraft came to a stop (Tab S-46). Photographs show that the nose wheel failed at approximately 150 ft off the end of the runway,

with the aircraft coming to rest approximately 306 ft from the departure end of runway 36L (Tab S-3).

f. Egress and Aircrew Flight Equipment (AFE)

Based on physical and photographic evidence the ejection seat inertia reels failed to restrain the MP during the rapid deceleration allowing the MP's visor to make contact with the Up Front Control (UFC) (Tabs S-26, S-34, V-1.16). Examination during the AIB disclosed that the inertia reels failed to consistently lock automatically when tested by the AIB Pilot Member (Tab GG-5).

The MP made no attempt to eject from the aircraft and performed a successful ground egress (Tab V-1.16). However, the F-16C Critical Action Procedures (CAPS) were not fully accomplished (Tab BB-3). Post mishap inspection revealed that the throttle was in the IDLE position in lieu of OFF (Tab S-17).

When the MA engine rolled back below approximately 55%, the Emergency Power Unit (EPU) activated after the loss of both the Main and Standby Generators (Tabs V-1.16, DD-30). The EPU ran for approximately 13 seconds and then shut down (Tab DD-30 – 31). The AIB was unable to determine if the shutdown was initiated by the MP during ground egress, or due to damage from engine ingestion of dirt and sod, and then was subsequently secured by ground personnel post mishap. The EPU switch was found in the off position in post mishap photos (Tab S-18).

g. Search and Rescue (SAR)

The MFL heard the MA impact the ground abeam his position and notified the tower for Fire and Rescue trucks to be rolled (Tab V-2.3). EAA and Wittman airfield operations personnel were at the scene immediately after the MA came to a stop (Tab GG-2). Wittman airport Aircraft Rescue and Firefighting (ARFF) trucks along with county Sherriff and representatives from the Federal Aviation Administration (FAA) arrived on scene in less than four minutes after the radio call from the MFL (Tab GG-2). Air Force Security Police (SP) secured the accident site at 1421L (Tab GG-3). The AIB found no attempt to isolate the MA for an activated EPU. The MA proved to be difficult to secure for mishap investigation purposes because of the location and air show operations tempo.

h. Recovery of Remains

Not applicable

5. MAINTENANCE

a. Forms Documentation

A detailed review of active and historical Air Force Technical Order (AFTO) Form 781 series aircraft maintenance forms revealed no discrepancies indicating engine, mechanical, or flight control anomalies existing on the MA prior to flight (Tab D-1). A thorough review of the active AFTO 781 forms and AFTO 781 historical records for the time period 90 days preceding the mishap revealed no evidence of mechanical, structural, or electrical failure that would have contributed to the mishap (Tab D1).

b. Inspections

The Integrated Maintenance Data System (IMDS) historical records for 90 days prior to the mishap were used to validate and confirm all forms entries (Tab D-2). None of the open Time Compliance Technical Orders (TCTOs) in the active forms restricted the MA from flying (Tab D2). TCTO compliance did not contribute to the accident. There was a slight discrepancy noted in IMDS on JCN 112030033 where the time listed for the 50 Hr Throttle Quadrant Inspection is most likely incorrect (Tab D2-25). The local unit does not have a night shift that would be performing the inspection from 0001 to 0100 (Tab D2-25). This minor discrepancy along with the corresponding throttle quadrant inspection is not suspected as a contributing factor to the mishap.

A Basic Post-flight/Pre-flight (BPO/PR) is a flight preparedness inspection performed by maintenance personnel prior to flight and is a valid inspection for 72 hours once completed. The BPO/PR inspections are performed IAW T.O. 00-20-1, Aerospace Equipment Maintenance Inspection, Documentation, Policies and Procedures. The purpose of the inspection is to visually inspect and operationally check various areas and systems of the aircraft in preparation for a flying period. The last PR inspection was completed on the morning of the mishap 28 July 2011 (Tab U-3).

c. Maintenance Procedures

There was no indication that any maintenance procedure, practice, or performance contributed to the mishap. There were no maintenance actions performed that appear related to the accident listed in IMDS or the MA forms documentation (Tab D).

d. Maintenance Personnel and Supervision

Pre-mission maintenance for the MA was performed by the 187th Fighter Wing Aircraft Maintenance Squadron (AMXS) personnel. All maintenance activities were normal and all personnel involved in the preflight, servicing, inspecting, and launch of the MA were qualified and proficient in their duties. Maintenance training records (AF Forms 623 and AF Forms 797) were reviewed and revealed no training deficiencies (Tab G).

e. Fuel, Hydraulic and Oil Inspection Analyses

Joint Oil Analysis Program (JOAP) samples from the MA engine and associated servicing carts were normal and no unusual volatiles were noted in the spectrum (Tab FF-9). Oil contamination is not suspected as a contributing factor to the mishap. Fuel samples from the fuel truck used to service the MA were normal and the material tested complied with T.O. 42B-1-1 requirements and was satisfactory for use (Tab FF-11). Fuel contamination is not suspected as a contributing factor in the mishap. Hydraulic fluid testing samples from the MA were not available. Hydraulic fluid contamination is not suspected as a contributing factor to the mishap.

f. Unscheduled Maintenance

Unscheduled maintenance is any maintenance action taken that is not the result of a scheduled inspection, and normally is the result of a pilot-reported discrepancy (PRD) during flight operations, or a condition discovered by ground personnel during ground operations. There was no relevant unscheduled maintenance that had any bearing on the mishap. The engine no go fault indicator was tripped the morning of the mishap (Tab D-48). Engine shop personnel downloaded the no go bit ball and troubleshot the problem IAW 1F-16C-2-70FI-00-11-1. No maintenance action was required (Tab D-48). All other unscheduled maintenance performed prior to the day of the mishap had no relevance on the accident (Tab D).

6. AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS.

a. Structures and Systems

Analysis of the Environmental Control System (ECS) and testimony from the MP have concluded that there was a malfunction of the ECS system that contributed to the mishap. This malfunction caused the defog system to fail and allowed increased moisture to create a fog condition in the cockpit (Tab Z-11). This condition prevented the pilot from being able to read the instruments or see outside of the cockpit (Tab V-1.11). Analysis of ECS system components and pilot testimony conclude that a failure in the ECS system prevented warm air from properly defogging the cockpit. This lack of warm air also contributed to an increase in cold air and moisture going to the cockpit. Depot engineers support the possibility of this conclusion whereby they propose that this condition could be caused by an ECS anti-ice valve that was faulty or was otherwise prevented from adding warm air to the cold turbine output, a faulty Cabin Temperature Control Valve, the warm air mix components/system, and maybe a fault in the MAX DEFOG circuitry (Tab DD-76). Various systems and components were recovered and tested (Tab HH). The analysis of the components directly related to the mishap are listed below.

b. Evaluation and Analysis

(1) Defog Lever

The Defog Lever provides the pilot a means to control and distribute cockpit airflow to prevent canopy fog or to offset solar heating effects (Tab BB-16). The defog lever can be positioned to various positions between MIN and MAX. The 3-minute time delay pull-in module provides for

a three-minute duration of warm air controlled to 158 degrees Fahrenheit to the forward canopy area (Tab BB-19). The results of lab testing concluded that the item met the criteria of the specific tests that were performed (Tab DD-11). The assembly passed required continuity tests per PL H16DW045-200 wiring harness-defog switch assembly and T.O. 1F-16C-2-00WD-00-4 in compliance with MIL-PRF-8805F with amendment 3 dated 14 June 2010 and repeated 20 times for confidence (Tab DD-11). See test results in summary of Table 1 (Tab DD-12). This item passed continuity tests but that does not guarantee that the system was functioning correctly. The 3-minute time delay pull-in module is activated by placing the defog lever to the MAX position. During normal operation, activation of the 3-minute time delay pull-in module will cause an increase in the cabin temperature control circuitry which will cause the Cabin Temperature Sensor/Controller to open the Cabin Temperature Control Valve and allow warm air to the forward canopy area (Tab BB-20). Testimony from the MP acknowledged that nothing happened when the defog lever was placed in the MAX position on at least two successive attempts during landing (Tab V-1.11). The MP testimony is consistent with photographs of fog in the cockpit (Tab Z-13).

(2) Environmental Digital Control Sensor/Controller (EDC)

The EDC senses cockpit airflow, turbine inlet temperature, cockpit temperature error, total (ram air) temperature, and available bleed air pressure (Tab BB-15). It computes cockpit flow demand and provides an output signal to the converter/transducer to modulate the Variable Air Pressure Regulator Shutoff Valve (VAPR SOV) (Tab BB-15). The EDC monitors and controls system and certain bay temperatures, provides system over-temperature protection by controlling ejector operation modulating bleed airflow, operates an ECS “cutback” mode during extreme system operating temperatures, and provides bleed flow optimization via low stage port selection when pressure is adequate (Tab BB-15). The initial operational bench test checkout revealed that the Analog Module was defective (Tab DD-61). Failure of this component may contribute to erratic ECS problems and possibly to the increased fog in the cockpit. A malfunction of this component or the associated sensing elements could cause a loss of warm air and reduced airflow if the system is receiving signals that the cockpit temperature is above the operational limit of 158 degrees Fahrenheit (Tab BB-20). The reduced airflow and lack of warm air would concur with the MP stating that air pressure was lost after going to MAX DEFOG (Tab V-1.11).

(3) Air Conditioning Matrix Assembly

The matrix assembly contains plug-in type units (relays or modules) that are used to control bleed air, cockpit temperature, and bay temperature functions (Tab BB-14). The matrix assembly was inspected at the 115th FW Madison, Wisconsin and all of their testing complied with specifications (Tab DD-73). The Cabin Temperature Control Valve Relay, Defog Relay, and 3-Minute Time Delay Pull In Module are critical to proper function of the defog circuitry and all three are located on this matrix assembly. Although the plug-in type units or modules passed basic testing, a malfunction of the units or the wiring associated with the matrix assembly could contribute to a lack of increased warm air when the defog lever is placed in the MAX position.

(4) Water Separator Coalescer

The coalescer collects and removes water from the air leaving the cooling air turbine compressor (Tab BB-18). The coalescer bands hold the coalescer tightly in place over the support grid through which the air must flow inside the separator (Tab BB-18). The top and bottom gaskets of the support grid show signs of wear, which will allow air to escape from the separator without removing the moisture (Tab Z-6). This condition will cause excessive moisture to buildup and transfer to the cockpit causing a fog condition (Tab Z-13). The fog condition will impair the pilot's vision and the ability to see outside the cockpit and read instruments (Tab Z-6).



(5) Anti-Ice Control Water Separator Modulating Valve

This is the valve portion of the water separator anti-ice control set (BB-17). The valve is modulated to mix warm air with turbine discharge cold air so as to prevent freezing of entrained moisture and icing of downstream components (BB-17). Testing, IAW Technical Order 15A2-16-34-3, revealed that the Anti-Ice Control Valve opened and closed, but it required approximately 10 mA more than Technical Order specifications allow to reach full open (Tab DD-4). This is usually the result of wear and tear. Overhaul shop records did not indicate that this serial number had been overhauled in the past two years (Tab DD-4). The history records maintained at depot revealed that there have been no other reported discrepancies with this valve (Tab DD-5). Possible malfunction of this valve could lead to icing in the system or increased moisture downstream if the valve has trouble modulating to the open position in order to provide sufficient warm air. The increase in moisture downstream will lead to additional fog in the cockpit.

(6) Anti-Ice Control Water Separator Sensor/Controller

The anti-ice control water separator sensor/controller is the sensor/controller portion of the water separator anti-ice control set (Tab BB-18). The set functions to provide 370 degree Fahrenheit air, as required, to increase the turbine discharge air temperature to a nominal 35 or 0 degrees Fahrenheit depending on mach and altitude (Tab BB-18). The readings across pins 1 and 2 at 80 degrees Fahrenheit should cause the sensor to read approximately 110 Ohms, and at 200 degrees it should read 130 Ohms (Tab DD-7). The sensor was tested at 80, 100, 200, and 300 degrees and all checks met specifications (Tab DD-7).

(7) Speedbrakes

The primary function of the speedbrake subsystem is to provide aerodynamic braking of the aircraft (Tab BB-22). The speedbrakes are actuated by depressing the SPD BRK switch on the throttle (Tab BB-22). Speedbrake malfunction is not suspected in this mishap.

7. WEATHER

a. Forecast Weather

The weather forecasted for takeoff at KMGM was VFR. The landing weather at Wittman Regional airport (KOSH), Oshkosh, WI was forecasted VFR from 1600Z (1100L) with winds variable at 3 knots, visibility 6 statute miles (sm) with mist, and a broken cloud layer at 1,600 ft above ground level (AGL) and improving conditions over the following four hours (Tab F-27).

b. Observed Weather

The previous day (27 July 2011) the Wittman regional airport received .76 inches of rain which saturated the airfield grounds (Tab W-3).

Prior to arrival, at 1553Z (1053L) the KOSH tower reported temperature 24° C (75° F), dewpoint 22° C (72° F), altimeter 29.93", winds from 080 degrees magnetic at 3 knots, visibility 5 sm with haze, broken cloud layer at 1,100 ft AGL and an overcast layer at 1,600 ft AGL. Runway 18R/36L was dry (Tab F-31). The temperature/dewpoint spread equated to a relative humidity of 88.62%.

Automated weather at 1609Z (1109L), just prior to mishap, reported winds from 100 degrees at 4 knots, visibility 2 and ½ sm with mist, and reported surface visibility of 5 sm (Tab F-29).

Post mishap the 1623Z (1123L) automated weather reported calm winds, broken cloud layer at 1,400 ft AGL and overcast layer at 1,900 ft AGL (Tab F-29).

c. Space Environment

Not applicable

d. Operations

The low ceiling drove the mishap flight to fly a lower and wider overhead pattern. Although evidence suggests that the pattern was executed appropriately, it was a contributing factor in the mishap.

Based on the forecast and prevailing conditions, the weather was in limits for the MS. Operations were conducted in accordance with AFI 11-202, Volume 3, *General Flight Rules*, 22 October 2010.

8. CREW QUALIFICATIONS

a. Mishap Pilot

The MP was a current Instructor Pilot/Standardization and Evaluation Flight Examiner (IP/SEFE) with a total time of 3533.1 hours in the F-16 prior to the mishap (Tab T-3). The MP had previously landed an F-16C at KOSH in 2003 and, in the previous week, landed a civilian WWII vintage fighter on the mishap runway (Tab V-1.17 – 18). The MP was familiar with military/war bird operations at AirVenture (Tab V-1.17). With the exception of Precision Approach currency, the MP met all other currency and training requirements prior to the mishap sortie, and was qualified for the mission as briefed and flown (Tab T-8).

Prior to the mishap sortie, the MP's recent flight time was as follows (Tab G-1.1.3):

	Hours	Sorties
Last 30 Days	2.8	2
Last 60 Days	7.3	6
Last 90 Days	20.5	15

MP qualifications were not contributory to this mishap.

9. MEDICAL

a. Qualifications - Mishap Pilot

The MP was medically qualified to perform flying duties at the time of the mishap (Tab EE-3). The MP's annual Preventative Health Assessment (PHA) was current (Tab EE-3). His 1042 was also up to date (Tab EE-3). Furthermore, the MP had no physical or medical restrictions and was worldwide qualified prior to the mishap (Tab EE-3).

b. Health

The MP had a minor medical condition that was not relevant to the mishap (Tab EE-3). On the days prior to the mishap, the MP's health was self-described as "fine" (Tab V-1.19). He was not in the care of physician for any medical condition (Tab V-1.20). Furthermore, on the day of the mishap, the MP ranked his overall health as an 8 on a scale of 1-10, with 1 being the worst he ever felt to 10 being the best (Tab V-1.20). He clarified this ranking by stating that he is "in good shape," "scores high on the fit test" and can perform "50 pushups and 50 sit-ups" as well as "run the mile and a half in 12 something" (Tab V-1.20). In addition, the MP suffered no significant injuries from the incident (Tab EE-3). Therefore, the MP's overall health was not a factor in this mishap.

c. Toxicology

Immediately following the mishap, toxicology testing was conducted by the Interim Safety Board (ISB) for all persons involved, including the MP, maintainers, and air traffic controllers. MP tested negative for illicit substances, along with ethyl alcohol and carbon monoxide (Tab EE-3). Testing also showed that all relevant maintenance personnel tested negative for illegal substances and all prescription medications were prescribed by health care providers for known conditions (Tab EE-3). Drugs, therefore, were determined not to be a factor in this mishap.

d. Lifestyle

The MP, MFL, and pertinent maintenance crew members, revealed no lifestyle factors, including unusual habits, behavior or stresses which were causal or substantially contributory to the mishap (Tab EE-4). The lifestyle of the MP was healthy with regular exercise, with frequent intake of fruits and vegetables, and avoidance of cigarettes, caffeine, and excessive alcohol intake (Tabs EE-4, V-1.20). The MP indicated that he slept well and received 7 to 9 hours of sleep the days prior to the mishap (Tab EE-4). Lifestyle factors were not relevant to this mishap.

e. Crew Rest and Crew Duty Time

Chapter 9.8 of AFI 11-202, Volume 3, requires all air crew to have proper “crew rest” prior to performing in-flight duties (Tab BB-3). Chapter 9.8 defines normal crew rest as a minimum of a twelve hour non-duty period before the designated flight duty period begins (Tab BB-3). During this time, an aircrew member may participate in meals, transportation, or rest as long as he or she has had at least ten hours of continuous restful activity with the opportunity for at least eight hours of uninterrupted sleep. The MP met crew rest requirements (Tab EE – 4). Fatigue or sleep deprivation was determined not to be a factor in this mishap.

10. OPERATIONS AND SUPERVISION

a. Operations

The 187th FW/100th FS had a normal operations tempo that was consistent with other Combat Air Forces (CAF) F-16C units. The 187th FW at the time was concurrently supporting a Ukrainian deployment and local continuation training (CT) flying at KMGM. The 187th FW has been flying the F-16 since 1988.

b. Supervision

Approval for this mission was fully supported by the Secretary of the Air Force for Public Affairs (SAF/PA) and the Alabama National Guard Adjutant General (NGAL/TAG). The MS was appropriately scheduled and approved by the 187th FW leadership (Tab HH-3 – 5). The Flight received a step brief from the Supervisor of Flying (SOF) and all operational risk management elements were appropriately covered (Tab V-1.3, 2.4).

11. HUMAN FACTORS

The board evaluated human factors relevant to the mishap using the analysis and classification system model established by the Department of Defense (DoD) Human Factors Analysis and Classification System (HFACS) guide, implemented by Air Force Pamphlet (AFPAM) 91-204, *USAF Safety Investigations and Reports*, dated 24 September 2008 (Tab BB-3). A human factor is any environmental, technological, physiological, psychological, psychosocial, or psycho-behavioral factor a human being experiences that contributes to or influences his performance during a task. The DoD has created a framework to analyze and classify human factors and human error in mishap investigations.

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

a. Causal

(1) PE101 Vision Restricted by Icing/Windows Fogged/Etc. *Vision Restricted by Icing/Windows Fogged/Etc is a factor when it is determined by the investigator that icing or fogging of the windshield/windscreen or canopy restricted the vision of the individual to a point where normal duties were affected (Tab BB-3).*

The fog caused the MP to lose “total visual,” which he found “disorienting” and similar to having a “white plastic bag” placed over his head (Tab V-1.5). The extreme fogging of the cockpit disoriented the MP, causing him to experience “vertigo” or “feel like there’s some movement happening when nothing really is happening” but in reality the movement is not as drastic as perceived (Tab V-1.20). In this regard, the fogging of the cockpit restricted the vision of the MP to a point where proper control of the aircraft was diminished or made extremely difficult (Tab Z-13). If not for the thick fog, the MP could have landed the aircraft safely (Tab Z-12).

Furthermore, the fog in the cockpit caused the MP to lose both inside and outside reference points. The MP stated that he “was able to just get a quick focus on the 140 and then nothing” (Tab V-1.13). Furthermore, the fog causing him to lose his reference point for the desired angle of attack in order to perform a proper aerobrake. He stated that “I just obviously wasn’t high enough” (Tab V-1.5--1.6). The fog caused the MP to lose track of his closure rate and ground speed, which ultimately led to an unsafe situation.

b. Contributory

(1) AE103 Procedural Error *Procedural error is a factor when a procedure is accomplished in the wrong sequence or using the wrong technique or when the wrong*

control or switch is used. This also captures errors in navigation, calculation or operation of automated systems (Tab BB-3).

Procedural error was determined to be a contributory factor to this mishap as the MP did not deploy the speedbrakes prior to touchdown (Tab V-1.18--1.19). This unintended error contributed to a faster touchdown speed and a longer touchdown distance (Tab GG).

The MP correctly managed the defogging procedure and this was not a factor. He reported engaging the defog lever at least twice but without effect (Tab V-1.11). He initiated this procedure in a timely manner (Tab V-1.19).

(2) PC106 Distraction *Distraction is a factor when the individual has an interruption of attention and/or inappropriate redirection of attention by an environmental cue or mental process that degrades performance (Tab BB-3).*

According to the MP's testimony, he may not have deployed the speedbrakes because the multiple tasks required to follow his lead to the runway distracted him. The MP did not recall why he did not use the speedbrakes, but opined that he may have been "preoccupied with the pattern or preoccupied with the traffic" or with "other stuff going on in the cockpit" (Tab V-1.18 – 1.19).

However, the MP was not distracted by the copious fog that obscured his vision. The MP's attention was not redirected; rather the fog in the cockpit caused the MP to become even more focused on the landing roll out, actually bringing the MP to a heightened sense of attention. In his interview, the MP states he was extremely concerned about the crowds to the left of the runway along with the other planes. Concerned that the "airplane was veering slightly to the left" and could threaten the safety of civilians and other aircraft, he focused on maintaining control and ruled out ejecting as an option in order to guide the plane safely (Tab V-1.20). Clearly, his attention was centered on completing a safe landing.

(3) PC511 Temporal Distortion *Temporal distortion is a factor when the individual experiences a compression or expansion of time relative to reality leading to an unsafe situation (Tab BB-3).*

The MP, denied any visual reference through the fog, experienced a perceptual quickening of time, describing it as a "very short time" in which everything "happened very quickly" (Tab V-1.20). He goes on to state that he realized, from a temporal standpoint, when he looked down and saw his speed was at "140" that, based on his extensive experience, his aero-brake was "nowhere near" what he needed (Tab V-1.12). This subjective experience of time compression relative to reality may have led to an unsafe situation in that the MP was unaware of ground speed (distance x time) and the fast approaching end of the runway. Although brakes were applied, the MP could not see the end of the runway and therefore did not receive a feedback response to determine if his braking was achieving the desired goal, namely to slow down the aircraft in a timely manner.

c. Non-Contributory

(1) PP201 Physical Fitness *Physical fitness is a factor when the relative physical state of the individual, in terms of a regular rigorous exercise program or a physically active lifestyle, is not adequate to support mission demands (Tab BB-3).*

After reviewing the MP's medical record and testimony in the interview, the MP was in excellent health, was not in the care of a medical provider, and maintained excellent physical fitness (Tab V-1.19). Therefore, it can be concluded that his physical fitness was not an issue in this mishap.

(2) SP005 Proficiency *Proficiency is a factor when an individual is not proficient in a task, mission, or event (Tab BB-3).*

The MP had over 3000 + flying hours in the F-16 over the course of his 28 year career and had flown on the 1st and 6th during the month of the mishap (Tab V-1.7). Proficiency was not a factor in this mishap.

(3) SP003 Limited Recent Experience *Limited recent experience is a factor when the supervisor selects an individual who's experience for either a specific maneuver, event or scenario is not sufficiently current to permit safe mission execution (Tab BB-3).*

Limited recent experience was non-contributory as he had flown 6 sorties in the 60 days prior and his currency for landing was up to date (Tab T-3).

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Directives and Publications Relevant to the Mishap

- (1) AFI 11-2F-16, Volume 3, *F-16 - Operations Procedures*, 18 February 2010
- (2) AFI 11-202, Volume 3, *General Flight Rules*, 22 October 2010
- (3) Air Force Tactics, Techniques, and Procedures (AFTTP) 3-3.F-16, *Combat Aircraft Fundamentals*, F-16, 30 March 2010
- (4) AFI 51-503, *Aerospace Accident Investigations*, 26 May 2010
- (5) Technical Order (T.O.) 1F-16C-1, Flight Manual, *USAF Series F-16C/D Blocks 25, 30, and 32 Aircraft*, 1 July 2010
- (6) TO 1F-16C-2-21GS-00-1, Technical Manual, Air Conditioning System, USAF Series, F-16C and F-16D Aircraft, Blocks 25, 30 and 32, 15 January 2009
- (7) TO 1F-16C-2-27GS-00-1, Technical Manual, Flight Control System, USAF Series, F-16C and F-16D Aircraft, Blocks 25, 30 and 32, 15 January 2009
- (8) TO 1F-16C-2-32GS-00-1, Technical Manual, Landing Gear System, USAF Series, F-16C and F-16D Aircraft, Blocks 25, 30 and 32, 15 December 2009
- (9) TO 1F-16C-2-49GS-00-1, Technical Manual, Emergency Power System, USAF Series, F-16C and F-16D Aircraft, Blocks 25, 30 and 32, 1 July 2010

b. Known or Suspected Deviations from Directives or Publications

All relevant known or suspected deviations from directives or publication have been addressed in the sequence of events.

13. ADDITIONAL AREAS OF CONCERN

None

28 SEP 2011

MICHAEL R. KELLEY, COL, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

**F-16C, T/N 87-0296
DANNELLY FIELD, AL
28 JULY 2011**

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

1. OPINION SUMMARY

I find by clear and convincing evidence that the cause of the mishap was extreme fogging in the MA cockpit, caused by the MA ECS, that completely obscured the MP's vision. I find by a preponderance of the evidence that substantially contributing factors were an inadequate aerobrake, a fast touchdown speed, and closed speedbrakes. The ECS had a significant impact on the MP's execution of normal landing procedures, and the lack of visual cues precluded his ability to stop the aircraft in the available runway distance.

On 28 July 2011, at approximately 1120 hours local time (L), an F-16C, tail number 87-0296, assigned to the 100th Fighter Squadron, 187th Fighter Wing, Dannelly Field, Alabama departed the prepared runway surface of Wittman Regional Airport (KOSH) causing \$5.4 million damage to the mishap aircraft (MA). The mishap pilot (MP) egressed the aircraft unharmed; there was only minor damage to Wittman Regional Airport.

The MP was number two of a two-ship formation on a continuation training (CT) mission to the AirVenture 2011 air show at KOSH. After an uneventful flight from Alabama to KOSH, the flight entered the airport landing pattern. During the MP's landing roll, the MA environmental control system (ECS) caused extreme fogging that completely obscured the MP's visual cues and severely affected the correct execution of his normal landing procedures. The MP correctly applied the defog procedure without effect, resulting in the MA running off the end of the airport's 8002 ft runway.

I developed my opinion by analyzing factual data from historical records, guidance and directives, engineering analysis, witness testimony, photographic evidence, the Crash Survivable Flight Data Recorder (CSFDR), flight simulations, and information provided by technical experts.

2. DISCUSSION OF OPINION

a. Cause: Extreme ECS fogging

The primary cause of the mishap was extreme fogging in the MA cockpit, caused by the MA ECS, that obscured the MP's vision. The ECS had a significant impact on the MP's execution of normal landing procedures, and the lack of visual cues precluded his ability to establish an effective aerobrake to stop the aircraft in the available runway distance. Without visual and instrument references, the MP cannot adjust the pitch attitude of the aircraft with any degree of precision.

b. Contributing Factors

(1) **Contributing Factor 1:** Less than 13 degree AOA aerobrake

A contributing factor was a less than 13-degree AOA aerobrake. The loss of both visual and instrument references prevented the MP from being able to execute a normal aerobrake, assess distance remaining or assess aircraft speed. From the CSFDR data, the AOA on the MA after touchdown varied between 5 and 11-degrees. Simulator reconstruction revealed that at 165 kts touchdown speed with less than a 13-degree AOA aerobrake landing distance could increase up to 7300 ft. Without any external inputs to the pilot, it is practically impossible to establish a valid aerobrake.

(2) **Contributing Factor 2:** Fast touchdown airspeed

Another contributing factor to the mishap was the fast approach and touchdown speeds. Landing data determined the MA approach speed for the landing weight of 24,500 lbs is 151 kts with a 140 kts touchdown speed, and a landing distance of 3092 ft with a properly flown aerobrake. The fast touchdown speed could be a result of the lower overhead altitude and slightly overshooting final requiring increased power inputs. F-16C landing data confirmed that for every 5 kts increase in touchdown speed a 400-ft increase in landing distance would result (speedbrakes open). However, without the ECS fogging, the MP would have been able to stop the aircraft on the runway even with the increased 5400 ft landing distance at the average touchdown speed of 170 kts.

(3) **Contributing Factor 3:** Closed speedbrakes

The speedbrakes are normally open during landing. Speedbrakes' primary purpose is to increase drag which at landing airspeeds provides for a higher power setting allowing for faster engine spool up in the event of go around. Photographic evidence revealed the MA speedbrakes were closed during the landing roll. Simulation verified the landing distance could increase 610 ft with the speedbrakes closed. With the average touchdown speed of 170 kts, the landing distance is 5400 ft. The additional 610 ft for speedbrakes closed results in a total landing distance of 6010 ft. Even though speedbrakes are normally open during landing, a correct aerobrake

would have stopped the aircraft on the runway even with the speedbrakes closed, with 1000 ft remaining.

3. CONCLUSION

I find by clear and convincing evidence that the cause of the mishap was extreme fogging in the MA cockpit, caused by the MA ECS, that completely obscured the MP vision. I find by a preponderance of the evidence that substantially contributing factors were a fast touchdown speed, an inadequate aerobrake, and closed speedbrakes. The ECS anomaly had a significant impact on the MP's normal landing procedure execution. The loss of visual cues affected not only proper aerobrake execution, but also his ability to assess distance remaining and aircraft speed.

28 SEP 2011

MICHAEL R. KELLEY, COL, USAF
President, Accident Investigation Board

Under 10 U.S.C. 2254(d), any opinion of the accident investigators as to the cause of, or the factors contributing to, the accident set forth in the accident investigation report, 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.