UNITED STATES AIR FORCE AIRCRAFT ACCIDENT INVESTIGATION BOARD REPORT

F-16D, T/N 88-0165

309TH FIGHTER SQUADRON
56TH FIGHTER WING
LUKE AFB, ARIZONA

LOCATION: LUKE AIR FORCE BASE, ARIZONA

DATE OF ACCIDENT: 26 JUNE 2013

BOARD PRESIDENT: COLONEL JOHN MENOZZI

CONDUCTED IAW AIR FORCE INSTRUCTION 51-503

EXECUTIVE SUMMARY
AIRCRAFT ACCIDENT INVESTIGATION

F-16D, T/N 88-0165
Luke Air Force Base, Arizona
26 June 2013

On 26 June 2013, at approximately 1856 hours local time (L), the Mishap Aircraft (MA), an F-16D, T/N 88-0165, assigned to the 309th Fighter Squadron, 56th Fighter Wing, Luke Air Force Base (AFB), Arizona, impacted the ground along the perimeter of Luke AFB at the southwest end of Runway 21R. The Mishap Instructor Pilot (MIP) and the Mishap Student Pilot (MSP) ejected safely, with the pilots sustaining minor injuries. The MA was destroyed upon impact, with limited damage to private property. Damage costs were estimated at $22,708,273.70.

The mission was scheduled, briefed, and executed as number one of a two-ship Transition Course (TX) sortie for the MSP with the MIP occupying the rear cockpit of the F-16D, in accordance with (IAW) USAF F-16 Transition/Requalification Training Course Track 2 syllabus. The mishap sortie was the MSP's second syllabus flight. After completion of the student's mission requirements, the MIP assumed control of the MA and executed a touch-and-go to update his backseat landing currency. Immediately following landing gear retraction on climb out from the MIP's touch-and-go, the MA ingested approximately three birds causing the engine to buzz, pop, and bang. Four seconds later, the MIP initiated a 45-60 degree bank, climbing right turn toward low key at approximately 190 Knots Indicated Air Speed (KIAS) and 20-25 degrees nose high. Approximately 90 degrees through this turn, the engine began producing a series of engine stalls, once every 3-5 seconds, coupled each time with an audible bang and aircraft shudder. After traveling through roughly 180 degrees of climbing turn, the MA apexed approximately 1,550 feet above ground level (AGL) and less than 110 KIAS. The MIP, perceiving an impending sink rate and engine failure, turned the aircraft toward an unpopulated area and directed ejection.

The Board President found by clear and convincing evidence that the cause of the mishap was a decision-making error by the MIP. After having clear indication of an engine malfunction on takeoff, the MIP made an immediate turn toward low key with insufficient airspeed and thrust to sustain a climb to either minimum controlled ejection altitude or low key. This error placed the MA in a slow-speed, nose-high attitude which, when coupled with further engine stalls, caused an unavoidable sink rate below minimum controlled ejection altitude. At this point, the MIP made a timely and accurate decision directing ejection.

The Board President also found by a preponderance of evidence that the following substantially contributed to the mishap: the MA ingested approximately three birds, resulting in a reduced thrust condition manifested by the engine compressor stalling every 3-5 seconds. Additionally, the following human factors were contributory to the mishap: Channelized Attention and Breakdown in Visual Scan.

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.

SUMMARY OF FACTS AND STATEMENT OF OPINION
F-16D, T/N 88-0165
26 June 2013

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COMMONLY USED ACRONYMS AND ABBREVIATIONS

AB Afterburner
ADO Assistant Director of Operations
AETC Air Education and Training Command
AF Air Force
AFB Air Force Base
AFE Aircrew Flight Equipment
AFI Air Force Instruction
AFPAM Air Force Pamphlet
AFTTP Air Force Tactics, Techniques, and Procedures
AGL Above Ground Level
AHC Aircraft Handling Characteristics
AIB Aircraft Investigation Board
AOA Angle of Attack
BMC Basic Mission Capable
BPO Basic Post-Flight Inspection
CAPS Critical Action Procedures
Capt Captain
CAS Close Air Support
Col Colonel
CRM Crew Resource Management
CSFDR Crash Survivable Flight Data Recorder
CCIP Common Configuration Implementation Program
CT Continuation Training
CUI Consolidated Unit Inspection
DEEC Digital Engine Electronic Control
DO Director of Operations
DoD Department of Defense
DVR Digital Video Recorder
ECS Environmental Control System
EP Emergency Procedure
EPE Emergency Procedures Evaluation
FAIP First Assignment Instructor Pilot
FITS Fighter Index of Thermal Stress
FLCS Flight Control System
FOD Foreign Object Damage
FRM Fighter Resource Management
FS Fighter Squadron
FTIT Fan Turbine Inlet Temperature
FTU Formal Training Unit
ft Feet
FW Fighter Wing
IAW In Accordance With
IDE Intermediate Developmental Education
ILS Instrument Landing System
IMIS Integrated Maintenance Information System
IP Instructor Pilot
IPUG Instructor Pilot Upgrade
JOAP Joint Oil Analysis Program
KCAS Knots Calibrated Airspeed
KIAS Knots Indicated Air Speed
L Local
L/D Max Lift Over Drag Maximum
Lt Col Lieutenant Colonel
MA Mishap Aircraft
Maj Major
MAJCOM Major Command
ME Mishap Engine
MF Mishap Formation
MIL Military Power
MIP Mishap Instructor Pilot
MP Mishap Pilot
MQT Mission Qualification Training
MSL Mean Sea Level
MSP Mishap Student Pilot
NOTAMS Notices to Airmen
OG Operations Group
OGV Operations Group-Standards and Evaluation Office
Ops Sup Operations Supervisor
Ops Tempo Operations Tempo
ORM Operational Risk Management
OSS Operation Support Squadron
P&W Pratt and Whitney
PHA Physical Health Assessment
PLF Parachute Landing Fall
RAPCON Radar Approach Control
RTB Return to Base
SA Situational Awareness
SAR Search and Rescue
SDR Seat Data Recorder
SEPT Situational Emergency Procedures Training
SFO Simulated Flame Out
SII Special Interest Item
SOF Supervisor of Flying
T/N Tail Number
TO Technical Order
TR Transition
TSI Training Solutions Incorporated
TX Transition Course
USAF United States Air Force
VFR Visual Flight Rules
WIC Weapons Instructor Course

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 20 August 2013, Lieutenant General James M. Holmes, Vice Commander, Air Education and Training Command appointed Colonel John Menozzi to conduct an aircraft accident investigation of a mishap that occurred on 26 June 2013 involving an F-16D aircraft, tail number (T/N) 88-0165, at Luke Air Force Base (AFB), AZ (Tab Y-3). The aircraft accident investigation was conducted in accordance with (IAW) Air Force Instruction (AFI) 51-503, *Aerospace Accident Investigations*, at Luke AFB, AZ, from 23 August 2013 through 17 September 2013. The following board members were also appointed: a Legal Advisor (Major), a Pilot Member (Captain), a Medical Member (Captain), a Maintenance Member (Master Sergeant), and a Recorder (Technical Sergeant) (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

On 26 June 2013, at approximately 1856 hours local time (L), the mishap aircraft (MA), an F-16D, tail number 88-0165, assigned to the 309th Fighter Squadron, 56th Fighter Wing, Luke AFB, AZ, crashed during a Transition (TR) Sortie and impacted the ground just outside the southwest fence line at Luke AFB (Tab Q-3). The Mishap Instructor Pilot (MIP) and Mishap Student Pilot (MSP) both ejected safely with only minor injuries (Tab Q-3). The MA was destroyed on impact (Tab J-12). Damage costs were estimated at $22,708,273.70 (Tab P-3).

3. BACKGROUND

The MA belonged to the 309th Fighter Squadron, 56th Operations Group, 56th Fighter Wing, Air Education and Training Command stationed at Luke AFB, AZ.

a. Air Education and Training Command (AETC)

AETC's primary mission is to develop America's Airman today for tomorrow. The command's vision is to deliver unrivaled air, space, and cyberspace education and training. The command's organization includes the Air Force Recruiting Service, one numbered air force, and the Air University. AETC has more than 56,000 active duty members, 4,000 Air National Guard and Air Force Reserve personnel, and 14,000 civilian personnel. The command is responsible for approximately 1,500 aircraft (Tab CC-1).

b. 56th Fighter Wing (56 FW)

The 56 FW's mission is to train F-16 pilots and crew chiefs while providing agile combat support for aerospace expeditionary forces. The wing is home to 196 F-16 aircraft and graduates more than 1,000 F-16 pilots and 900 crew chiefs annually (Tab CC-9).

c. 56th Operations Group (56 OG)

The 56 OG's mission is to train and produce the world's finest F-16 pilots and crew chiefs for the United States and allied forces and to train personnel and maintain resources to meet contingency and wartime taskings. The 56 OG has operational control and responsibility for the entire fighter-training mission at Luke AFB. The group is composed of an operations support squadron, a training squadron, eight squadrons of F-16s, and two detachments (Tab CC-13).

d. 309th Fighter Squadron (309 FS)

The 309 FS is responsible for training the world's finest fighter pilots and maintenance technicians in support of around-the-clock mission readiness. On April 1, 1994, the Air Force activated the squadron as part of the 56th Fighter Wing at Luke AFB, AZ (Tab CC-13).

e. F-16 Fighting Falcon

The F-16 Fighting Falcon is a compact, multi-role fighter aircraft. It is highly maneuverable, has proven itself in both air-to-air combat and air-to-surface attack, and provides a relatively low-cost, high-performance weapon system for the United States and allied nations. In an air combat role, its maneuverability and combat radius (distance it can fly to enter air combat, stay, fight and return) exceed that of all potential threat fighter aircraft. It can locate targets in all weather conditions and detect low flying aircraft in radar ground clutter. In an air-to-surface role, the F-16 can fly more than 500 miles, deliver its weapons with superior accuracy, defend itself against enemy aircraft, and return to its starting point. An all-weather capability allows it to accurately deliver ordnance during non-visual bombing conditions (Tab CC-15).

4. SEQUENCE OF EVENTS

a. Mission

The mission was scheduled, briefed, and executed as number one of a two-ship Transition Course (TX) sortie for the MSP with the MIP occupying the rear cockpit of the F-16D, IAW United States Air Force (USAF) F-16 Transition/Requalification Training Course syllabus (Tab K-9) utilizing the callsign RADON 11. The sortie included a departure to assigned airspace, formation flying, introductory aircraft handling characteristics (AHC) maneuvering, practice instrument approaches, and Visual Flight Rules (VFR) patterns including touch-and-go landings (Tab V-3.4). The mishap sortie was the second flight in the TX syllabus (Tab K-9).

b. Planning

The MSP and MIP planned the mission IAW the TX syllabus (Tab V-1.3). The MIP briefed the sortie using the 309 FS Standard Transition Brief (Tab V-1.3), which covered all administrative flight information, weather, Notices to Airmen (NOTAMs), Special Interest Items (SIIs), and all items necessary to safely conduct the flight (Tab V-1.4). There were no NOTAMs affecting the airfield or pattern the day of the mishap.

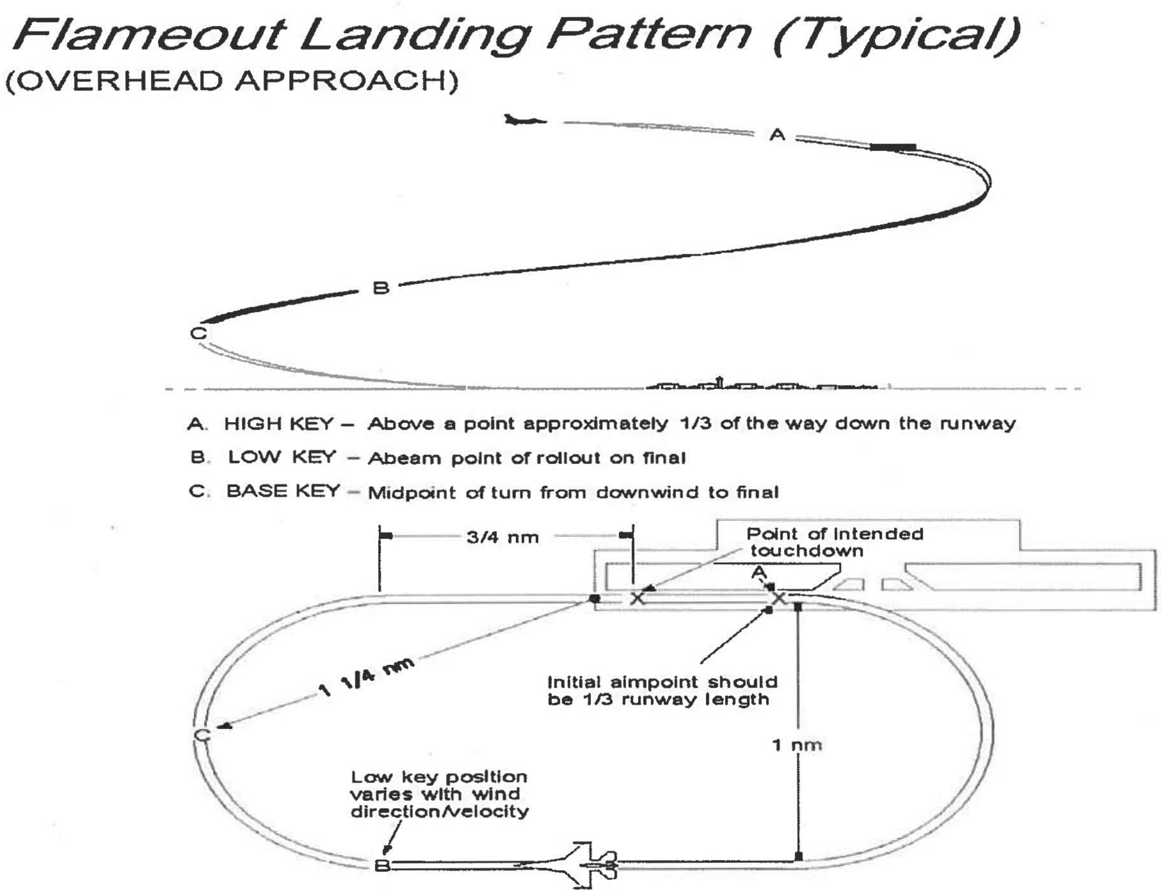
c. Preflight

Prior to the mission brief, the MSP and MIP accomplished all required Go/No-Go items IAW 56 OG Instruction 11-1, *Operations Procedures*, and 56 FW *Standards*, including completion of a 56 FW Operational Risk Management (ORM) worksheet for the mishap mission (Tabs G-83 through 85, G-152 through 155, K-41 through 42). The MIP and the Operations Supervisor (Ops Sup) approved the ORM worksheet (Tabs K-41 through 42). According to AFI 90-901, *Operational Risk Management*, 1 April 2000, paragraph 1, "operational risk management is a decision-making process to systematically evaluate possible courses of action, identify risks and benefits, and determine the best course of action for any given situation." The MSP assessed the risk level for the mission as Green and the MIP and Ops Sup confirmed that assessment (Tabs K-41 through 42). Green is the lowest level of risk for a mission on a three-color scale – Green/Yellow/Red (Tabs K-41 through 42). Following the mission brief, the MSP and MIP donned their appropriate aircrew flight equipment and arrived at the operations desk at approximately 1650L for a final update briefing from the Ops Sup on weather, NOTAMs and other pertinent safety-of-flight information prior to proceeding, or "stepping," to the aircraft (Tab V-1.4). The Bird Watch Condition was assessed and briefed as Low (Tab V-13.1). The MA's preflight inspections were accomplished IAW all applicable technical order procedures and no deficiencies were noted (Tab V-1.4). Ground and taxi operations for the sortie were uneventful (Tab V-1.4).

d. Summary of Accident

The Mishap Formation (MF) start/taxi/takeoff and departure were all uneventful and IAW local standards and syllabus execution. The MF conducted formation practice and then split into two separate elements in the airspace to conduct AHC maneuvers before exiting the airspace for a penetration and Instrument Landing System approach at the auxiliary airfield. Following this approach, the MA entered the Luke AFB pattern through a visual straight-in followed by three uneventful Simulated Flameout (SFO) patterns and two uneventful overhead patterns, all of which were IAW the 56 FW syllabus for a TR-3 sortie. (Tab V-1.5).

The SFO pattern allows pilots to practice landing the aircraft after the loss of the engine. The same pattern is flown anytime the engine is actually lost or in a situation where the reliability of the engine is in question (e.g. loss of oil, abnormal engine operation, etc.) The pattern consists of three different "key" positions, which are locations above and around a suitable landing runway that allow the maneuver of the aircraft to touchdown without power. The first is "high key," which is 7,000-10,000 feet above ground level (AGL) in the same direction as the intended landing. This position allows a transition to "low key," which is 180 degrees out from the landing direction at 3,000-5,000 feet AGL, offset approximately one mile. The final "key" is "base key," which is 2,000 feet AGL, an altitude that corresponds to the minimum altitude at which the gear should be lowered and an ejection should be made if landing cannot be assured. High and low key altitude as well as airspeeds flown are dependent on the current weight in fuel and stores on the aircraft. Reaching one of the "key" locations provides the best possible assurance of a successful flameout landing. The following diagram shows the basic SFO pattern layout (Tab BB-8).



(Tab BB-8)

Flying a normal overhead pattern permits quicker recovery of a large number of aircraft and/or multiple practice approaches and landings. Aircraft enter the pattern level at 1,500 feet AGL down the centerline of the intended landing runway at 300 KIAS. At the approach end of the runway, the aircraft makes a level break turn to end up approximately one mile laterally offset from the runway at 200 KIAS. The pilot lowers the landing gear and initiates a descending turn while slowing to final approach speed and ensuring that the Angle of Attack (AOA), or amount of pitch angle compared to flight path, is maintained at 11-13 degrees through touchdown. If performing a touch-and-go, the pilot moves the throttle back to military power (MIL) and holds rotation attitude until airborne. Once airborne with a positive rate of climb, the pilot raises the landing gear and continues the climb while holding rotation attitude. When performing multiple patterns, the fastest and most typical action is to request a closed pattern on the go. In accordance with Air Force Tactics, Techniques, and Procedures (AFTTP) 3-3.F-16, flying a closed pattern requires accelerating on runway heading until reaching a minimum of 250 KIAS before requesting a closed pattern from the tower. A smooth climbing turn brings the aircraft to pattern altitude (1,500 AGL) at 200-250 KIAS, placing it in the same position as a normal overhead after the break (Tab BB-2).

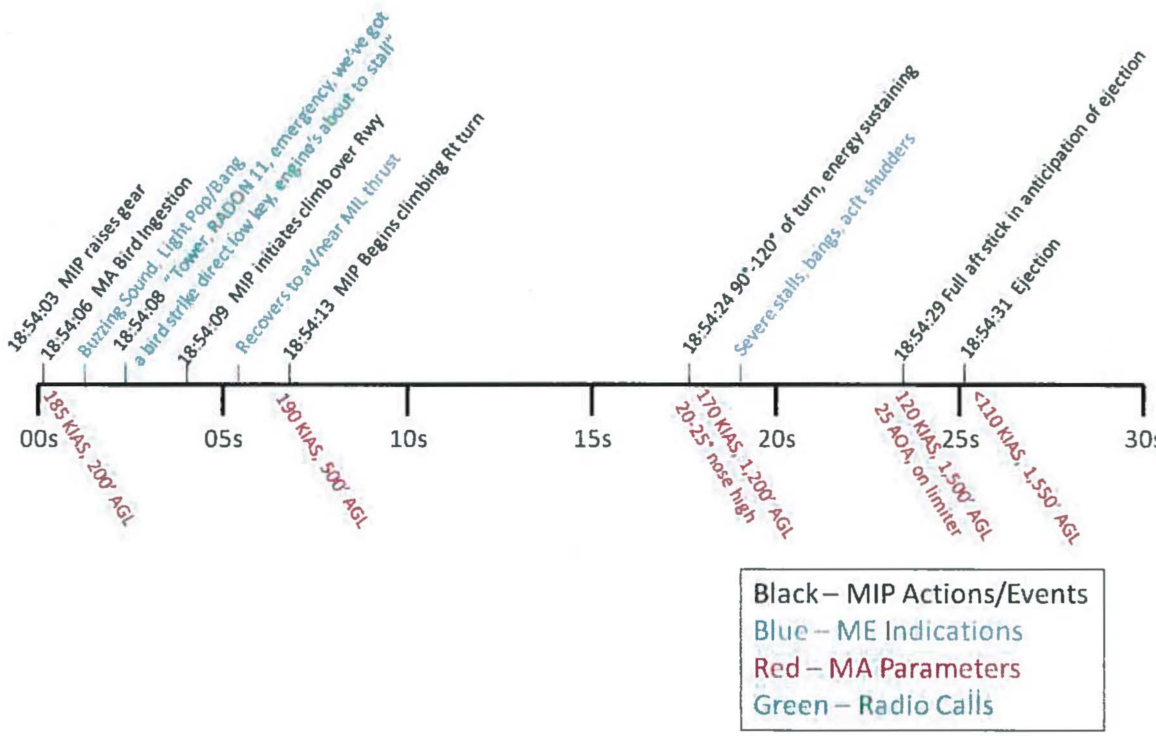
Following the uneventful pattern practice by the MSP, the MIP took control of the MA and completed a touch-and-go landing from the backseat to update currency (Tab V-1.6). Shortly following landing gear retraction from the MIP's touch-and-go at 1854:06L and immediately after seeing several small dark flashes, which were ultimately identified as three small birds, pass adjacent the right side of the aircraft engine intake, the MSP noticed an acrid smell in his mask and voiced this to the MIP (Tab V-3.6). In addition to the smell, there was a low grade buzzing sound, which both the MSP and MIP attributed as an abnormal engine noise indicating something may have gone down the intake (Tab V-1.8). The buzzing appeared to cease after one to two seconds, but was followed by a light pop and bang, which the MIP recognized as a pending engine stall or failure (Tab V-1.8). The front cockpit Instructor Pilot (IP) from HONKER 11, who was approximately 4,000 feet behind RADON 11, observed an orange flame and sparks from the back of the mishap engine (ME) at this time (Tab V-5.1).

At 1854:09L, the MIP began an initial climb, approximately 15 degrees nose high on runway heading, which he maintained for three to four seconds (Tab V-1.8). No observation or analysis of engine instruments was accomplished at this time by either the MSP or MIP, although both stated that they perceived the aircraft to be accelerating normally in MIL at this point (Tabs V-1.8, V-3.6). Following this initial climb, the MIP perceived the engine to be operating at full military thrust, but was concerned about a potential impending engine failure (Tab V-1.9). As a result, the MIP's emphasis was to "maintain airspeed while climbing in order to get back to some key position before the engine stalled," a point from which he could then land if further engine malfunctions occurred (Tab V-1.9). At 1854:13L, the MIP initiated an immediate climbing right turn (20 to 25 degrees nose high) to low key at approximately 190 KIAS, 500 feet AGL, and just past the midpoint of Runway 21R (Tabs V-1.9, V-3.6, FF-1).

At approximately 1854:24L, roughly 90 degrees through the climbing turn toward low key, airspeed decreased through 170 KIAS as the ME began a stall sequence, with a louder and more violent bang preceding three to five compressor stalls (Tabs V-1.9, V-3.6). The MIP, perceiving engine failure and an inability to attain a key position, transitioned his emphasis to maneuvering the MA away from populated areas in preparation for ejection (Tab V-1.9). Two seconds prior to ejection, at 1854:29L, the MA was at approximately 1,500 feet AGL, 110-127 KIAS, heading 040 with full aft stick applied (25.16 degrees AOA) (Tab L-22). At no point during the climbing turn, the level off, or when maneuvering prior to ejection did the MSP or MIP conduct a visual scan to reference or analyze their engine or performance instruments (Tabs V-1.9, V-3.6, V-3.13). The throttle remained set at full MIL throughout the mishap sequence (Tab V-1.10).

The MA reached its pre-ejection apex at approximately 1,550 feet AGL with airspeed less than 110 KIAS on a heading of 020 (Tabs H-5 through H6). At this point, the MIP perceived that full aft stick was no longer holding level flight and directed ejection, with both pilots pulling the ejection handle at 18:54:31L (Tab V-1.10).

Following the ejection, the MA descended to 1,100 feet AGL and subsequently recovered to a climbing left hand turn toward the northwest (Tab FF-1). The MA reached a point 3.5-4 nautical miles north/northwest of the airfield and an altitude of approximately 6,000 feet AGL before beginning a sharp left-hand turn back toward Luke AFB (Tab FF-1). The MA then descended toward the airfield, passing HONKER 11 (providing rescue overwatch for RADON 11) from high to low, and impacted just outside the southwest fence line of Luke AFB after approximately two minutes of post-ejection flight (Tab V-5.2).



MA and ME Performance Analysis:

High fidelity data on the mishap sequence was not available due to the Crash Survivable Flight Data Recorder (CSFDR), Digital Engine Electronic Control (DEEC), and Digital Video Recorder (DVR) not surviving the crash (Tabs J-6, J-14, J-19). The Seat Data Recorder (SDR) did survive and was merged with Luke AFB Radar Approach Control (RAPCON) radar data to produce a flight profile re-creation of the mishap sequence with airspeed, altitude and flight path through the time of ejection (Tabs S-11, FF-3). Analysis was exclusively radar-derived for flight path, altitude, and airspeed post-ejection through aircraft impact (Tab FF-1).

The raw data accuracy from the SDR is limited due to the low frequency of recordings to the SDR and the use of airspeed and altitude range windows to record normal data measurements (Tabs L-13, J-15 through J-19). The SDR samples the airspeed, true heading, and altitude of the aircraft every 15 seconds (Tabs L-13, J-15 through J-19). If a Flight Control System (FLCS) related switch actuation occurs (e.g. raising/lowering the gear handle) or FLCS related Maintenance Fault List occurs, the SDR will record an additional reading with greater fidelity, including aircraft attitude, side-stick inputs, AOA, and flight control surface position at the time of the event (Tabs L-13, J-15 through J-19). The recorded airspeed and altitude are measured and reported as the lowest number in that range (e.g. airspeed of 126 Knots Calibrated Airspeed (KCAS) is recorded as 110 KCAS since the range is 110-127 KCAS) (Tabs FF-9 through FF-10). The relevant ranges recorded during the mishap sequence are:

Airspeed (KCAS)	Altitude (feet AGL)
110-127	651-771
167-178	180-290
179-188	1,753-1,877

Data from the radar system provided to RAPCON is reported every 4.6 seconds based on aircraft transponder reported altitude and position (Mode 3 and C) in conjunction with radar skin paints from multiple sources (Tabs FF-11 through FF-12). Additionally, tracks are classified by aircraft type, allowing a predictive flight algorithm based on potential performance (Tabs FF-11 through FF-12). The displayed airspeed is calculated by the radar based on time elapsed and distance between transponder positions each cycle (Tabs FF-11 through FF-12). This data is more accurate for altitude than for airspeed, which was corroborated by the SDR data and witness interviews (Tabs FF-11 through FF-12). The Air Force Mishap Analysis and Animation Facility produced a re-creation of the mishap sequence using a combination of the SDR and RAPCON data (Tab S-11).

The absence of high fidelity engine data from onboard sources led the board to use the F-16 simulator as a tool to evaluate ME performance by flying the ground track, altitudes, and airspeeds recorded by the SDR and RAPCON data at different power settings to determine which most closely matched the actual MA performance. The simulator was able to replicate the same configuration, fuel weight, and environmental settings from the day of the mishap. Data from the SDR and RAPCON showed the MA reaching an altitude of 1,550 feet AGL, less than 110 KIAS, and a heading of 030 at the time of ejection (Tab FF-5).

The following table shows the aircraft parameters at the onset of a sink rate when flying the MA ground track at the specified power setting:

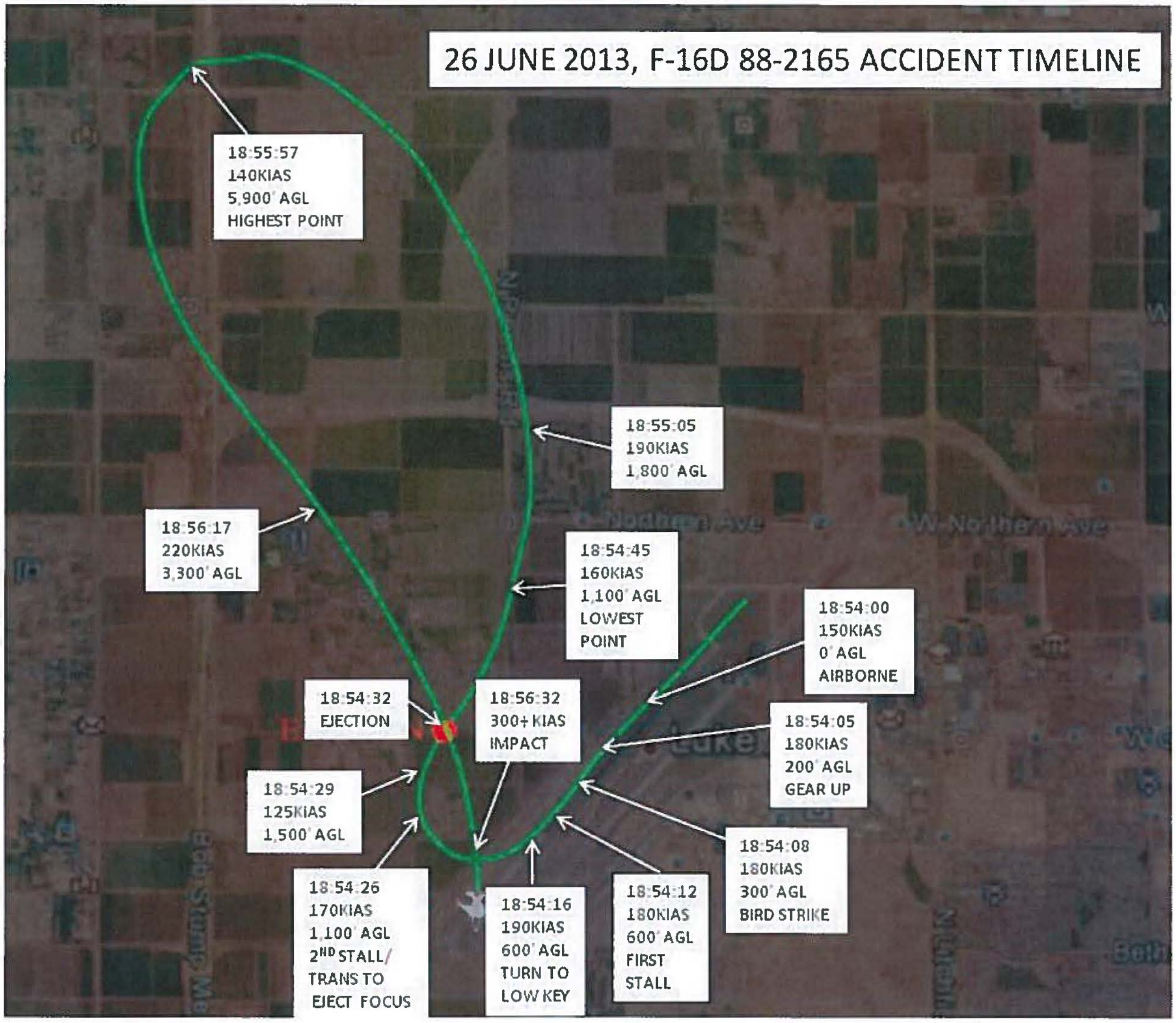
Power Setting	Sink rate onset parameters
Mil (96%)	HDG 032, 1,780' AGL, 123 KIAS, 25 AOA
90%	HDG 030, 1,340' AGL, 94 KIAS, 25 AOA
Idle	HDG 260, 570' AGL, 90 KIAS, 25 AOA
Mil, stalls entered every 3-5 seconds	HDG 030, 1,050' AGL, 114 KIAS, 25 AOA

These simulations show that achieving the same flight path profile, headings, airspeeds, and altitude would have required an energy sustaining (180 KIAS) pull until 1,200 feet AGL, followed by a limiter pull to 1,550 feet AGL with the ME operating between 90-95% power on average during the mishap sequence (Tab FF-5).

In addition to the simulator data, the engineering evaluation of the ME at ground impact was operation at or near MIL (Tab J-9). This data, along with the flight profile of the MA after ejection and witness testimony, demonstrates that the ME continued providing near full military thrust through impact despite going through periodic stalls (Tab FF-1). These findings are consistent with the ME entering both stall recovery logic and the newly implemented Fan Damage Detection Logic (FDDL) (Tab FF-5). Stall recovery logic automatically performs functions to clear the stall and resume the power requested by the throttle, which may induce further stalls after recovery (Tab J-7). If a stall occurs every time power above a certain setting is attempted, the DEEC will assume some kind of damage has occurred to the engine and it will enter FDDL (Tab J-7). This logic prevents the engine from attempting to provide power at or above the setting which induces the stall condition and, instead, runs the engine at the maximum power possible without inducing a stall (Tab J-7).

TO 1F-16CM-1 directs pilots to avoid turns during engine malfunctions so that time and altitude can be maximized to either recover engine performance or prepare for ejection (Tabs BB-2, BB-5). Additionally, the TO states that 250 KIAS is the approximate airspeed at which minimum thrust is required for level flight. (Tab BB-6) Interviews with multiple IPs and academics instructors confirmed that the expected response to an engine malfunction occurring at low-altitude and slow speed is to climb straight ahead to minimum controlled ejection altitude while attempting to increase speed to 250 KIAS before attempting any follow on maneuvering (Tabs V-6.1, V-8.1, V-9.2, V-10.1).

In order to assess the ability to successfully recover the MA, the TO recommended profile was flown with power settings as low as 80% in the simulator to determine whether sufficient thrust existed to sustain a straight-ahead climb. Even with continuous stalls every three to five seconds, the airspeeds achieved in a straight ahead climb provided a large enough margin in airspeed to allow the engine to recover from multiple stalls before a sink rate became unavoidable. Recovery to a key position within the known window at which the ME continued to operate (a minimum of 2 minutes 30 seconds) was also possible at power settings lower than exhibited by the ME (Tab FF-5).



Tab FF-3

e. Impact

The MA impacted the terrain at approximately 1856L on 26 July 2013 at the southwest corner of Luke AFB (Tab FF-1). Estimates indicate that the MA was traveling in excess of 300 KIAS, heading 180, wings level with a low to moderate negative pitch angle at the time of impact (Tab J-12). The wreckage debris field spread south from the impact crater across the south end of Runway 21R, closing that runway until the investigation and cleanup was conducted (Tab J-12).

Tabs S-1, S-3

f. Egress and Aircrew Flight Equipment (AFE)

The MIP and MSP were wearing all appropriate AFE for a daytime TX sortie (Tab H-9). All required AFE inspections were current (Tab H-9). The MIP and MSP simultaneously initiated a successful Mode I ejection within the performance envelope of the Advanced Concept Ejection Seat II ejection system with the ejection selection handle in "Aft" (Tab H-8). The MIP and MSP initiated ejection at approximately 1,550 feet AGL – below recommended controlled ejection altitude of 2,000 feet AGL (Tab FF-5). The MIP did not pull the 4-line jettison on his canopy, leading to significant oscillations and a hard landing, which contributed to his injuries (Tab V-1.12). All AFE and escape system components recovered from the mishap site were in serviceable condition and functioned as designed, with the exception of the MSP's emergency beacon, which had a faulty battery (Tab I-4).

g. Search and Rescue (SAR)

The MIP and MSP were in contact with local civilians within minutes of hitting the ground. A local civilian emergency medical technician was on the scene within ten minutes to provide medical assistance. Luke AFB medical personnel, including a flight surgeon, arrived in an ambulance shortly thereafter to take control of the aircrew and transport to the Aerospace Medicine Clinic at Luke AFB (Tab V-1.13).

h. Recovery of Remains

Not applicable.

5. MAINTENANCE

a. Forms Documentation

The 56th Maintenance Group (56 MXG), 756th Aircraft Maintenance Squadron (756 AMXS), Luke AFB, maintained the aircraft forms for the MA. Tracking aircraft maintenance is accomplished via the Integrated Maintenance Data System (IMDS), while the Air Force Technical Order (AFTO) Form 781 series is used to document various maintenance actions. A detailed review of the MA's IMDS and AFTO Form 781s showed no evidence to suggest any maintenance correlation to the mishap (Tabs D-3 through D-20, D-24).

b. Inspections

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 TO 00-20-1, *Aerospace Equipment Maintenance Inspection, Documentation, Policies, and Procedures*. The purpose of the Pre-Flight 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 25 June 2013 at 2105L. A Thru-flight inspection was completed after the first sortie of the day on 26 June 2013 at 1500L with no discrepancies identified IAW TO 00-20-1. The Thru-flight inspection is a "between flights" inspection and is accomplished after each flight when a turnaround sortie or a continuation flight is scheduled and a BPO inspection is not required. The Production Superintendent completed an Exceptional Release (ER) prior to the first and second flight of the day with no discrepancies noted during either inspection. An ER is a forms inspection and is required before flight; it serves as a certification that the authorized individual reviewed the active forms to ensure the aircraft is safe for flight. All scheduled inspections were completed IAW applicable TO guidance with no discrepancies noted (Tabs D-3, D-4).

c. Maintenance Procedures

In the 24 hours prior to the mishap, pre-flight servicing and routine operational checkouts were performed, to include an engine inlet inspection, aircraft fuel servicing, and liquid oxygen servicing. All servicing and inspection procedures completed on the day of the mishap were IAW applicable aircraft TOs and did not contribute to the mishap (Tabs D-4 through D-10).

d. Maintenance Personnel and Supervision

MXG personnel perform all field-level maintenance on Luke AFB's F-16s. A thorough review of maintenance records for personnel performing maintenance functions on the MA within 24 hours of the mishap revealed no training deficiencies. All maintenance personnel involved in the servicing or inspecting of the MA are qualified and proficient in their duties. Maintenance personnel and supervision did not contribute to the mishap (Tabs U-2.1, U-2.2, U-3.1, U-3.2).

e. Fuel, Hydraulic and Oil Inspection Analyses

Pre-mishap Joint Oil Analysis Program (JOAP) samples from the MA, and associated servicing carts, were normal and no unusual volatiles noted in the spectrum. Oil contamination was not a contributing factor to the mishap (Tab D-1). Fuel samples from the fuel truck and fuel tank used to service the MA were normal and the material tested complied with TO 42B-1-1, *Quality Control of Fuels and Lubricants* requirements and was satisfactory for use. Fuel contamination was not a contributing factor in the mishap. Hydraulic fluid was not analyzed because the aircraft had not been serviced with hydraulic fluid in the last five sorties. Post mishap testing samples from the MA for hydraulic fluid, JOAP, and fuel were not available. All fluid materials met requirements with respect to the tests conducted. Contamination was not a contributing factor to the mishap (Tab U-1).

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 during flight operations or a condition discovered by ground personnel during ground operations. The MA flew 306.8 hours following the post-phase with no unscheduled maintenance that had any bearing on the mishap.

6. AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS

a. Structures and Systems

The MA impacted the ground at over 300 KIAS causing the engine and other MA components to suffer severe crushing damage. Pratt and Whitney engineers conducted an evaluation of the engine (Tabs J-1 through J-9) and Lockheed Martin Aeronautics performed an SDR and hardware analysis (Tabs J-11 through J-23). Most cockpit hardware, the DVR, Data Transfer Cartridge (DTC), and the CSFDR System were either not recovered or too damaged for analysis (Tabs J-14 and J-19).

b. Evaluation and Analysis

The MA collapsed upon itself on impact and was destroyed. However, some components were recoverable and intact enough for analysis. The component analysis indicated that all systems were operating normally, the aircraft impacted at over 300 KIAS, and the emergency power unit was not operating at impact (Tabs J-12 and J-22).

7. WEATHER

a. Forecast Weather

From 1400L until 2100L, the forecast for Luke AFB was for winds from the south (heading 200) at 12 knots, 10 statute miles visibility, and sky clear (Tab F-1). IAW AFI 11-202, Volume 3, *General Flight Rules*, the Fighter Index of Thermal Stress (FITS) was in the Danger zone. FITS is a tool to help supervisors and aircrew determine when the outside temperature reaches a point at which aircrew thermal stress can become a factor in performance. FITS Danger limits the pilot to no more than 45 minutes on the ground before engine start and a minimum of 30 minutes in an air-conditioned environment between flights.

b. Observed Weather

The observed weather at the time of the mishap was winds heading 240 at 9 knots, 10 statute miles visibility, and sky clear (Tab F-25) . Temperature was 102 degrees Fahrenheit (39 degrees Celsius), which corresponds to FITS Danger.

c. Space Environment

Not applicable.

d. Operations

Weather at the time of the mishap, even with temperature in the FITS Danger zone, was well within limits and not a factor.

8. CREW QUALIFICATIONS

a. Mishap Instructor Pilot

The MIP is a current and qualified F-16 IP and met required flying continuity training (Tab G-1). The MF was the MIP's first sortie of the day (Tab V-3.4). The MIP had a total of 1,080.8 flight hours and 796.7 flight hours in the F-16 (Tab G-5). The MIP was current on all Go/No-Go items (Tab G-83 through G-85). The MIP completed his initial Instructor Pilot Upgrade (IPUG) training and been an instructor at Luke AFB since December 2012 (Tab G-91) .

Recent flight time is as follows (Tab G-1):

	Hours	Sorties
Last 30 Days	18.5	13
Last 60 Days	28.5	21
Last 90 Days	44.3	32

b. Mishap Student Pilot

The MSP was undergoing re-qualification in the F-16 through the TX course Track 2 (Tab G-156). The MF was the MSP's first sortie of the day and second in the TX course (Tab V-3.4). The MSP had a total of 2,163.7 flight hours and 1,931.1 flight hours in the F-16 (Tab G-36). The MSP was current on all Go/No-Go items (Tab G-152 through G-155). The MSP was participating in re-qualification training due to non-flying assignments for the previous 42 months; his last flight before beginning the TX course was on 30 November 2009 (Tab G-35).

Recent flight time is as follows (Tab G-31):

	Hours	Sorties
Last 30 Days	1.5	1
Last 60 Days	1.5	1
Last 90 Days	1.5	1

There is no evidence to suggest crew qualifications were a factor in this mishap.

9. MEDICAL

a. Flying Qualifications

(1) Mishap Instructor Pilot

The MIP was medically qualified for flying duties at the time of the mishap. The MIP's most recent annual military Periodic Health Assessment (PHA) was performed on 9 August 2012. The MIP's annual dental examination was performed on 30 July 2012 (Tab X-1). His medical records contained a current Air Force Form 1042, Medical Recommendation for Flying or Special Operational Duty, dated 9 August 2012 (Tab X-1). Review of the Aeromedical Information Management Waiver Tracking System (AIMWTS) database, a computer system for tracking aircrew medical waivers, showed that the MIP did not have a medical waiver at time of the mishap (Tab X-1). Physical and medical qualifications of the MIP were not factors in this mishap.

(2) Mishap Student Pilot

The MSP was medically qualified for flying duties at the time of the mishap (Tab X-1). The MSP's most recent annual military PHA was performed on 25 January 2013. The MSP's annual dental examination was performed on 25 January 2013 (Tab X-1). His medical records contained a current Air Force Form 1042, dated 25 January 2013 (Tab X-1). Review of the MSP's medical chart showed that the MSP had an indefinite waiver granted by AETC on 12 April 1996 which is not found in the AIMWTS database as the waiver was created prior to the existence of AIMWTS (Tab X-1). Physical and medical qualifications of the MSP were not factors in this mishap.

(3) Air Traffic Controllers (ATCs)

At the time of the mishap, two ATCs were monitoring local control and both were medically qualified for controller duties at the time of the mishap (Tab X-1). After review of their medical records, their records each contained a current Air Force Form 1042 (Tab X-1). Review of AIMWTS database, showed that one ATC had a valid waiver approved by AETC on 1 January 2012 and expires on 31 January 2015 (Tab X-1). Physical and medical qualifications of the ATCs were not factors in this mishap.

b. Health Prior to Mishap

(1) Mishap Instructor Pilot

The Accident Investigation Board (AIB) Medical Member reviewed the medical and dental records in addition to the 72-hour/14-day histories of the MIP. The MIP's records reflected he was in good health and had no recent performance-limiting illnesses prior to this mishap (Tab X-1). Based upon this review, the MIP was in good health and had no recent medical or psychological conditions that contributed to the mishap.

(2) Mishap Student Pilot

The AIB Medical Member reviewed the medical and dental records in addition to the 72-hour/14-day histories of the MSP. The MSP's records reflected he was in good health and had no recent performance limiting illnesses prior to this mishap (Tab X-1). The MSP does have chronic right shoulder pain, but this condition neither limited him physically nor contributed to the mishap (Tab X-1). Based upon this review, the Mishap Instructor Pilot was in good health and had no recent medical or psychological conditions that contributed to the mishap.

c. Injuries

The MIP and the MSP successfully ejected from the MA (Tabs H-8, V-1.12 through V-1.13, V-3.9). There were no fatalities of military personnel or local civilians. Local emergency responders, including civilian Emergency Medical Services personnel, as well as a flight surgeon and other military personnel from Luke Air Force Base recovered the pilots (Tabs V-1.13, V-3.10 through V-3.11). The MIP and MSP were taken to the Aerospace Medicine Clinic on Luke Air Force Base to conduct a post-mishap physical examination and to obtain blood and urine samples (Tabs V-1.13, X-1).

(1) Mishap Instructor Pilot

During the evaluation by the flight surgeon, the MIP complained of mild injuries during his parachute landing fall (Tabs V-1.12, X-1). These included right elbow and upper arm bruising with some minor abrasions, pain in the right shoulder blade, and a mild abrasion on the forehead (Tabs V-1.12, X-1). X-rays of the right elbow, skull, cervical spine, thoracic spine, and lumbar spine noted no acute radiologic findings (Tab X-1).

(2) Mishap Student Pilot

During the evaluation by the flight surgeon, the MSP complained of mild right shoulder pain and soreness and left hand soreness (Tabs V-3.16, X-1). X-rays of the right shoulder, left hand, cervical spine, thoracic spine, and lumbar spine noted no acute radiologic findings (Tab X-1).

d. Toxicology

Immediately following the mishap and in accordance with safety investigation protocols, blood and urine samples were collected and submitted to the Armed Forced Medical Examiner System at Dover Air Force Base in Delaware for toxicological analysis. Blood samples for both the MIP and MSP tested within normal limits for carbon monoxide levels and negative for ethanol (Tab X-1). Blood testing for all maintainers was negative for ethanol (Tab X-1). For the MIP, MSP, and all maintainers, urine drug screen testing was negative for amphetamine, barbiturates, benzodiazepines, cannabinoids, cocaine, opiates, and phencyclidine by immunoassay or chromatography (Tab X-1). Toxicology was not performed on the two ATCs (Tab X-1).

e. Lifestyle

Witness testimony, 14-day/72-hour histories, and the medical charts of the MIP and MSP revealed no lifestyle factors relevant to the mishap (Tab X-1). Review of the medical charts of the maintainers and ATCs revealed no lifestyle factors relevant to the mishap.

f. Crew Rest and Flight Duty Period

Air Force Instruction (AFI) 11-202, Volume 3, *General Flight Rules*, dated 22 Oct 2010, prescribes mandatory crew rest and maximum Flight Duty Periods (FDP) for all personnel who operate USAF aircraft (Tab X-4 through X-6). Based upon witness testimony and supplemental history, crew rest was deemed not to be a factor in this mishap and was in accordance with paragraph 9.8 of this AFI (Tabs X-1, V-1.3, V-2.7 through V-2.8, V-3.3 through V-3.4, V-3.14 through V-3.15). Based upon witness testimony and supplemental history, there was no violation of the FDP by the MIP or the MSP (Tabs X-1, V-2.7 through V-2.8, V-3.3 through V-3.4).

10. OPERATIONS AND SUPERVISION

a. Operations

The 309 FS maintains an operations tempo consistent with other squadrons at Luke AFB. The total flying hours and pilot manning has not changed significantly over the years, providing a relatively stable tempo. Recent challenges include an increase in the number of inbound F-16 instructors who require a full Track 1 IPUG Training program. These prospective IPs arrive without prior instructor qualifications and require additional sorties and a longer upgrade program. This places some stressors on the squadron's ability to simultaneously conduct the F-16 Basic Course. Despite this, the operations tempo is well managed to enable quality student training. A review of the squadron flying roster showed a robust number of IPs (over 40), providing ample resources to execute the daily flying schedule and allow enough time for proper preparation and debrief (Tabs V-9.4 through V-9.5).

An in-depth review of the Luke AFB Bird Aviation Strike Hazard (BASH) program found the program execution and oversight to be IAW applicable regulations (Tab V-13.1). Interviews conducted with airfield operations personnel and United States Department of Agriculture base representative validated bird counts were conducted the morning of the mishap as well as at midday and sunset (Tabs V-12.1, V-13.1). These counts indicated a low number of birds observed, resulting in a Bird Condition "Low" being maintained throughout the day (Tabs V-12.1, V-13.1). Pilots from aircraft in the pattern at the time of the mishap observed no bird activity on the airfield prior to the MA ingesting birds on climb out from the touch-and-go (Tabs V-4.2, V-13.12). Neither the BASH program nor operations were a factor in this mishap.

b. Supervision

The mission was authorized by the 309 FS Ops Sup on an Aviation Resource Management System Flight Authorization Form (Tabs K-7 through K-8). The flight received a step brief from the Ops Sup and all ORM elements were appropriately covered (Tab V-8.1). Supervision is actively engaged in monitoring pilot weekly and monthly work schedules to manage workload (Tab V-9.4). Supervision was not a factor in this mishap.

11. HUMAN FACTORS

a. Introduction

The AIB 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 AFI 91-204, *Safety Investigations and Reports,* dated 24 September 2008. A human factor is any environmental, technological, physiological, psychological, psychosocial, or psycho-behavioral factor a human being experiences that contributes to or influences task performance. The DoD has created this framework to analyze and classify human factors and human error in mishap investigations. The framework consists of four main categories: Acts, Preconditions, Supervision, and Organizational Influences. Each category is subdivided into related human factors. This framework allows for a complete analysis of all levels of human error, including their interaction, to determine their contribution to the mishap (Tabs X-7 through X-36).

b. Causal Human Factor

AE206 Decision-Making During Operation

Decision-Making During Operation is a factor when the individual, through faulty logic, selects the wrong course of action in a time-constrained environment.

After hearing a slight "rumbling" sound and the MSP questioning an abnormal smell just after gear retraction, the MIP recognized that an object might have entered the intake of the MA. (Tab V-1.8). This provided the MIP with "some sort of indication that the engine may be about to stall or fail" (Tab V-1.8). His immediate action was to bring the nose of the MA up to increase altitude, achieving an altitude of approximately 500 feet Above Ground Level (AGL). The MIP completed a radio call: "Tower, Radon 11, emergency ... we've got a bird strike, direct low key, engine's about to stall" (Tab N-1), indicating that he assessed an engine malfunction just after gear retraction following the bird strike (Tabs V-1.13, V-2.3). In response, the MIP initiated an energy-sustaining right turn from 500 feet AGL at 190 KIAS, 20-25 degrees nose high, and a 45-60 degree bank (Tabs V-1.9 through V-1.10, V-2.5, FF-5). This decision is not IAW TO 1F-16CM-1 guidance or standard procedures taught and practiced across the F-16 community (Tab BB-5, V-6.1).

According to TO 1F-16CM-1, during an engine malfunction after take-off, "[i]f takeoff is continued, a straight ahead climb is generally preferred over an immediate turn to low key. This action provides more favorable ejection parameters and an increase in analysis time" (Tab BB-5). Fundamental lift/drag principles dictate that a turn reduces the vertical lift component available for a climb, thereby limiting the ability to gain altitude and time available for analyzing the situation and restoring usable thrust, both of which are essential for dealing with a critical engine malfunction low to the ground. Simulations flown by the AIB Pilot Member showed that a climb straight ahead, with even greater reductions in thrust than exhibited by the ME, would have provided the airspeed and altitude needed to permit the DEEC to recover the engine prior to a sink rate (Tab FF-5).

The MIP's decision to turn immediately to low key after a low altitude engine malfunction was causal. Although the MIP initially maintained an energy-sustaining turn with full military thrust, this course of action (COA) reduced the margin of error available for pilot error or subsequent aircraft/engine malfunction significantly below the margin afforded by a straight ahead climb. Once the ME stalled in this lower portion of the performance envelope, there was no airspeed available to trade for either time or altitude. Thus, the DEEC could not recover engine performance prior to a sink rate developing, making ejection the only correct option.

c. Contributory Human Factors

PC102 Channelized Attention/AE105 Breakdown in Visual Scan

Channelized attention is a factor when the individual is focusing all conscious attention on a limited number of environmental cues to the exclusion of others of a subjectively equal or high or more immediate priority, leading to an unsafe situation.

A Breakdown is Visual Scan is a factor when the individual fails to effectively execute learned/practiced internal or external visual scan patterns leading to an unsafe situation.

After assessing a bird strike and possible engine malfunction on climb out from his touch-and-go, the MIP made multiple statements about his desire to reach low key as quickly as possible. His initial reaction was to "maintain airspeed while climbing in order to get to a key position before the engine stalled" (Tab V-1.9). The MIP went on to state that "we had just been performing multiple closed pull-ups, multiple SFOs, which may have factored into my decision to try to get back to a landable position.... I want to get away from the ground and attempt to get to a place where it may be recoverable if something happens down the road" (Tabs V-1.15 through V-1.16). Reaching low key became the sole focus of his attention, to the exclusion of completing an analysis of engine operation and flight parameters (Tabs V-1.8, V-2.3 through V-2.4). A lack of analysis prevented the MIP from considering any alternative COAs (e.g. climbing straight, applying Low Thrust on Takeoff Critical Action Procedures). This channelized attention on reaching low key contributed to the MIP's decision to make the immediate turn at low altitude and low airspeed.

Additionally, the MIP channelized on maneuvering the MA to a low-key position to the exclusion of monitoring flight parameters and engine instruments. The MIP spent the entire mishap sequence looking outside with no cross check of airspeed, altitude, or engine revolution per minute (Tabs V-1.9, V-1.14). This led the MIP to improperly analyze a series of engine stalls as an engine failure prior to making a decision to eject (Tab V-2.5). While it was too late at this point in the mishap sequence to have averted the sink rate, the MIP's failure to scan is further evidence of severe channelized attention. The channelization was only broken when the MIP perceived a loss of thrust and onset of a sink rate, at which point he switched his focus to preparing for ejection (Tab V-1.9).

d. Other Notable Human Factors

(1) PC103 Cognitive Task Oversaturation/PP102 Cross-Monitoring Performance

Cognitive Task Oversaturation is a factor when the quantity of information an individual must process exceeds their cognitive or mental resources in the amount of time available to process the information.

Cross-monitoring Performance is a factor when crew or team members failed to monitor, assist, or back-up each other's actions and decisions.

The MSP was on his second sortie of the F-16 Track 2 TX course at Luke AFB (Tab V-3.3). Although he had 1,931 hours in the F-16, the MSP's last sortie in the F-16 prior to returning to the TX course was in November 2009 (Tabs G-35, G-38). Given this lack of recent experience in the cockpit of an F-16, the stall caught the MSP "off-guard" and he "wasn't ready for something like that" (Tab V-3.8).

The low altitude and low airspeed at which the mishap sequence began, coupled with the quick decision to turn, created an immense sense of compressed time for the MSP thereby restricting, in his mind, the time available for crew coordination to determine an appropriate action (Tab V-3.7). Indeed the MSP conveyed his feeling that he "could not express [that they should have gone straight ahead] over the radios at the time" (Tab V-3.8). Additionally, the MSP attributes his failure to conduct an internal visual scan of the cockpit and analyze the situation to his lack of recent flight experience and his focus outside the cockpit (Tabs V-3.12 through V-3.13).

The MSP was cognitively task saturated which led him to not fully evaluate the situation or provide valuable cross-monitoring of the on-going circumstances. Since it is impossible to know whether the outcome of this mishap would have changed if the MSP had interjected to facilitate crew coordination, determining whether it was causal or contributory is not feasible. However, there was a missed opportunity to break the chain of events that eventually led to the mishap.

(2) PC405 Technical/Procedural Knowledge

Technical/Procedural Knowledge is a factor when an individual was adequately exposed to the information needed to perform the mission element but did not absorb it. Lack of knowledge implies no deficiency in the training program, but rather the failure of the individual to absorb or retain the information. (Exposure to information at a point in the past does not imply "knowledge" of it.)

In an effort to understand why the MIP, with a known engine malfunction at low altitude and slow speed on takeoff, chose to attempt a climbing turn to low key instead of climbing straight ahead, the AIB asked a series of general knowledge questions to each of the nine F-16 pilots and simulator instructors interviewed. These questions not only focused on what procedures TO 1F-16CM-1 and AFTTP 3-3 prescribe for an engine malfunction on takeoff, but also what reference airspeeds and techniques AFTTP 3-3 proscribes for executing a closed pull-up, or a smooth, climbing turn to pattern altitude (Tab BB-2).

All interviewees stated that the proper response to an engine malfunction on takeoff is to climb straight ahead (if able) to minimum ejection altitude while attempting to accelerate toward 250 KIAS (the approximate airspeed at which thrust required for level flight is the lowest) (Tabs V-8.1, V-9.2, V-10.1). When asked this same question by the AIB, the MIP quoted the same basic TO 1F-16CM-1 procedure for an engine malfunction on takeoff, indicating that he was aware of this guidance (Tabs V-2.6 through V-2.7).

When queried about reference airspeeds and techniques for initiating a closed pull-up in the F-16, the consensus response across all interviewees was: accelerate to 250-300 KIAS and then turn using a blend of pitch, bank, power and pull to roll out at proper downwind altitude and spacing between 200-250 KIAS (Tabs V-8.1, V-9.2, V-10.1). This aligns with guidance in AFTTP 3-3, and was validated through review of several HUD video tapes of actual student missions (Tab BB-2).

However, when the MIP was asked about closed pull-up reference airspeeds, he was unaware of an AFTTP 3-3 reference airspeed range and stated that he normally requests and pulls closed between 200-250 KIAS and "had no issues pulling closed" with airspeeds between 200-300 KIAS (Tab V-2.4). RAPCON and SDR data from the MIP's closed pull-up just prior to his touch-and-go showed he initiated the pull-up and turn at approximately 210 KIAS, accelerating in his climb and rolling out on downwind at 240 KIAS (Tabs L-29, FF-7).

Although reviewed as an item of interest by the board, the MIP's lack of procedural knowledge and the closed pattern execution did not contribute to this mishap under a preponderance of the evidence standard. However, it is possible that his perceived comfort level in pulling closed at slower speeds could have factored into his willingness to pursue this COA when faced with the extreme stress of dealing with a worst case scenario of an engine malfunction on takeoff.

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Publically Available Directives and Publications Relevant to the Mishap

(1) AFTO Form 781, *ARMS Aircrew/Mission Flight Data Document*, 11 Sep 08
(2) AFI 11-202, Volume 3, *General Flight Rules*, 22 Oct 10
(3) AFI 11-202, AETC Supp., *General Flight Rules*, 22 Oct 12
(4) AFI 13-204, Volume 3, *Airfield Operations Procedures and Programs*, 1 Sept 10
(5) AFI 90-901, *Operational Risk Management*, 1 Apr 00
(6) AFI 91-202, Change 2, *The Air Force Mishap Prevention Program*, 20 Aug 13
(7) AFI 91-202, *The Air Force Mishap Prevention Program*, 19 Jun 12
(8) AFI 91-204, *Safety Investigations and Reports*, 24 Sept 08
(9) AFPAM 91-212, *Bird/Wildlife Aircraft Strike Hazard (BASH) Management Techniques*, 1 Feb 04

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

b. Other Directives and Publications Relevant to the Mishap

(1) 56 FW Combined Wingman Syllabus, *SPINS*, 21 May 13
(2) 56 FW OPLAN 91-2, *Bird/Wildlife Aircraft Strike Hazard (BASH) Reduction Plan*, 26 Apr 13
(3) 56 FW, *Standards*, 15 Oct 12
(4) 56 OG OI 11-1, *Operations Procedures*, 15 Feb 11
(5) 56 OSS OI 13-204, *Airfield Management*, 15 Sept 11

(6) AFTTP 3-3.F-16, *Combat Aircraft Fundamentals, F-16*, 14 Jun 13
(7) Luke AFBI 13-204 *Airfield Operations and Base Flying Procedures*, 2 Apr 12
(8) TO 00-20-1, *Aerospace Equipment Maintenance Inspection, Documentation, Policies, and Procedures,* 1 Apr 13
(9) TO 1F-16CM-1, *F-16C and F-16D CCIP Aircraft Blocks 40/42/50 and 52*, 1 Aug 12
(10) TO 42B-1-1, *Quality Control of Fuels and Lubricants*, 19 Nov 12

c. Known or Suspected Deviations from Directives or Publications

None.

13. ADDITIONAL AREAS OF CONCERN

Not applicable.

[redacted]

17 September 2013

JOHN J. MENOZZI, Colonel, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

F-16D, T/N 88-0165
LUKE AFB, ARIZONA
26 JUNE 2013

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

On 26 June 2013, at approximately 1856 hours local time (L), the mishap aircraft (MA), an F-16D, tail number 88-0165, assigned to the 309th Fighter Squadron, 56th Fighter Wing, Luke Air Force Base (AFB), AZ crashed near the western boundary of the airfield. The mishap student pilot (MSP) and mishap instructor pilot (MIP) ejected safely. The MSP and the MIP sustained minor injuries during landing. The MA was destroyed on impact, with limited damage to private property. Mishap damage costs are estimated at $22,708,273.70.

The mishap occurred on the MSP's second sortie in the Transition Training Course Track 2 syllabus. The transition sortie profile consisted of basic formation, advanced handling characteristics, instrument approach work, and Visual Flight Rules pattern work. The sortie began uneventfully, with the MSP accomplishing all planned mission events. After completion of the mission profile, the MIP took control of the aircraft to fly an overhead pattern on Runway 21R and update his backseat landing currency. The MIP's pattern and landing were uneventful until the MA's engine ingested approximately three small birds following gear retraction on the touch-and-go. Almost instantaneously, the engine began making a buzzing noise and the MSP noticed a strong, acrid smell in his oxygen mask. The buzzing appeared to cease after one to two seconds, but was followed by a light pop and bang. Perceiving a possible engine malfunction, the MIP, still in control of the MA, began a climb over the runway followed four seconds later by a climbing turn in military power toward low key at approximately 190 Knots Indicated Air Speed (KIAS). Approximately 90 degrees through this turn, the engine began producing a series of compressor stalls, once every 3-5 seconds, coupled each time with an audible bang, aircraft shudder, and noticeable loss of thrust. After traveling through roughly 180 degrees of climbing turn, the MA apexed approximately 1,550 feet above ground level (AGL) and less than 110 KIAS. The MIP, perceiving an impending sink rate and engine failure, turned the aircraft toward an unpopulated area and directed ejection.

I find by clear and convincing evidence that the cause of the mishap was a decision-making error by the MIP. After having clear indications of an engine malfunction on takeoff, the MIP made an immediate turn toward low key with insufficient airspeed and thrust to sustain a climb to either minimum controlled ejection altitude or low key. This error placed the MA in a slow-speed, nose-high attitude which, when coupled with further engine stalls, caused an unavoidable sink rate below minimum controlled ejection altitude. At this point, the MIP made a timely and accurate decision directing ejection.

I find by a preponderance of evidence that the following factor substantially contributed to the mishap: the MA ingested approximately three small birds, resulting in a reduced thrust condition manifested by the engine compressor stalling every 3-5 seconds. Additionally, the following human factors were contributory to the mishap: Channelized Attention and Breakdown in Visual Scan.

I developed my opinion by analyzing factual data from: historical records, engineering analysis, witness testimony, flight data, flight simulations, animated simulations, information provided by technical experts, and Air Force Directives, Technical Orders (TO), and guidance.

2. CAUSE

Decision-Making During Operation

TO 1F-16CM-1 establishes three basic rules which apply to all emergencies: (1) Maintain aircraft control; (2) Analyze the situation and take proper action; and (3) Land as the situation dictates. The TO further states that during an engine malfunction on takeoff,

> If takeoff is continued, a straight-ahead climb is generally preferred over an immediate turn to low key. This action provides more favorable ejection parameters and an increase in analysis time.

Additionally, AFTTP 3-3.F-16 states that, during an emergency on takeoff,

> Obtaining altitude and airspeed is the primary goal. Execute Critical Action Procedures (CAPS) and continue straight ahead until within ejection parameters (2,000 feet AGL). Once assured of the ability to climb/accelerate, use shallow turns and reduce gross weight as much as practical. Be prepared to eject if the situation deteriorates beyond your capability to prevent a sink rate from developing.

These statements direct a straight-ahead climb as optimum to maintain aircraft control and analyze the situation in response to any engine malfunction on takeoff.

The MIP's decision to turn immediately to low key vice climbing straight ahead after recognizing an engine malfunction on takeoff at low altitude and slow speed was causal. The MIP initiated an immediate turn to low key at 190 KIAS with an engine malfunction of unknown severity. The turn reduced lift available for a climb while also reducing airspeed below the point that thrust from the stalling Mishap Engine (ME) could maintain level or climbing flight. Additionally, it limited the time available to fully analyze the situation, successfully recover engine performance or prepare for ejection.

Although the MIP initially maintained an energy-sustaining turn with full military thrust, this course of action reduced the margin of error available for pilot error or subsequent aircraft/engine malfunction significantly below the margin afforded by a straight-ahead climb. Once the ME stalled in this lower portion of the performance envelope, there was no airspeed available to trade for either time or altitude. Thus, the ME could not recover thrust prior to a sink rate developing. Upon reaching an apex below minimum controlled ejection altitude and unable to hold level flight, the MIP made a correct and timely decision to initiate ejection.

Had the MIP elected to climb straight-ahead, it is my opinion that the ME was producing enough thrust to permit a climb above minimum controlled ejection altitude and acceleration to minimum recommended maneuvering airspeed. Although the ME exhibited stalls every 3-5 seconds during the turn to low key, simulator re-creation of MA flight path and ME performance prior to ejection indicated an average minimum thrust level in excess of 90%. Engineering technical evaluation of the ME at ground impact was operation at or near full military power. This data, along with the flight profile of the MA after ejection and witness testimony, demonstrates that the ME, despite periodic stalls, continued providing sufficient thrust for enough time to have safely recovered the aircraft.

3. SUBSTANTIALLY CONTRIBUTING FACTORS

a. Bird Ingestion

The MA ingested approximately three small birds after gear retraction on a touch-and-go landing, resulting in the ME immediately exhibiting signs of a malfunction followed by a sequence of stalls and recoveries. This created a worst-case emergency for a single-engine aircraft: low and slow with a questionable ability to produce thrust.

b. Channelized Attention/ Breakdown in Visual Scan

After assessing a bird strike and possible engine malfunction on climb out from his touch-and-go, the MIP, concerned about a potential impending engine failure, focused solely on "maintaining airspeed while climbing in order to get back to some key position before the engine stalled." He also stated that "we had just been performing multiple closed pull-ups, multiple SFOs, which may have factored into my decision to try to get back to a landable position." Reaching low key became the sole focus of his attention, to the exclusion of completing an analysis of engine operation or flight parameters. A lack of analysis prevented the MIP from considering any alternative COAs (e.g. climbing straight-ahead, applying Low Thrust on Takeoff CAPs). This channelized attention on reaching low key contributed to the MIP's decision to make the immediate turn at low altitude and low airspeed.

The MIP spent the entire turn looking outside with no cross check of airspeed, altitude, or engine performance. This led the MIP to improperly analyze a series of engine stalls as an engine failure prior to making the decision to eject. While it was too late at this point in the mishap sequence to have averted the sink rate, this lack of scan is further evidence of severe channelized attention. This channelization was only broken when the MIP perceived a loss of thrust and onset of a sink rate, at which point he switched his focus to preparing for ejection.

I find by a preponderance of the evidence that this channelized attention and breakdown in visual scan contributed to the MIP's failure to properly assess the situation and follow TO guidance, thereby contributing substantially to the mishap.

4. CONCLUSION

By clear and convincing evidence, I find the cause of the mishap was pilot error. The MIP made a decision-making error during operation by turning to low key rather than climbing straight ahead, which caused the mishap. Further, I find by a preponderance of evidence that bird ingestion and the MIP's channelized attention and breakdown in visual scan substantially contributed to the mishap.

[redacted]

17 September 2013

JOHN J. MENOZZI, Colonel, USAF
President, Accident Investigation Board

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