

UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION
BOARD REPORT



F-16C, T/N 93-0531 and F-16C, T/N 92-3899

**157TH FIGHTER SQUADRON
169TH FIGHTER WING**

McEntire Joint National Guard Base, South Carolina



LOCATION: LOUISVILLE, GEORGIA

DATE OF ACCIDENT: 7 JUNE 2016

BOARD PRESIDENT: BRIG GEN RANDAL K. EFFERSON

Conducted IAW Air Force Instruction 51-503



DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR COMBAT COMMAND
JOINT BASE LANGLEY-EUSTIS VA

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23 APR 2018

ACTION OF THE CONVENING AUTHORITY

The Report of the Accident Investigation Board, conducted under the provisions of AFI 51-503, that investigated the 7 June 2016 mishap involving two F-16Cs, T/N 93-0531 and 92-3899, 157th Fighter Squadron, 169th Fighter Wing, McEntire Joint National Guard Base, South Carolina, complies with applicable regulatory and statutory guidance; on that basis it is approved.

//Signed//

JOHN K. MCMULLEN
Major General, USAF
Deputy Commander

**United States Air Force Accident Investigation Board Report
F-16C (2x) Mishap, Louisville, GA**

**EXECUTIVE SUMMARY
UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION**

**F-16C, T/N 93-0531 and F-16C, T/N 92-3899
LOUISVILLE, GA
7 JUNE 2016**

On 7 June 2016, at approximately 2114 local, two F-16C Block 52 aircraft collided head-on during a training mission in the Bulldog Military Operating Area near Louisville, Georgia (GA). Following the collision, both pilots ejected safely, suffering minor injuries. Mishap Pilot 1 (MP1) is assigned to the 316th Fighter Squadron, 169th Fighter Wing, McEntire Joint National Guard Base (JNGB), South Carolina (SC). Mishap Pilot 2 (MP2) is assigned to the 157th Fighter Squadron, 169th Fighter Wing, McEntire JNGB, SC. Mishap Aircraft 1 (MA1, tail number 92-3899) and Mishap Aircraft 2 (MA2, tail number 93-0531) are assigned to the 157th Fighter Squadron, 169th Fighter Wing, McEntire JNGB, SC. Both aircraft were destroyed after impacting the ground in a rural area of approximately four square miles, with damage to private property (timber). The total aircraft loss is approximately \$60,798,131.00.

MP1, a recently assigned, active duty, experienced F-16C instructor pilot, was the flight leader undergoing an additional 169th Fighter Wing instructor pilot qualification program. MP2, also an experienced F-16C instructor pilot, was responsible for administering the upgrade while flying in a visual (wedge) formation several miles behind MA1. The mishap occurred 10 minutes after civil twilight, in the latter phase of a training mission. After MP2 issued a low fuel (Bingo) call, MP1 executed a sharp left turn at an altitude of 15,000 feet mean sea level (MSL) (MP1's assigned sanctuary altitude). "Bingo" is a pre-briefed fuel state that, when reached, requires termination of tactical maneuvering and return to base with normal recovery fuel. MP2, approximately 4 nautical miles (nm) behind at 16,000 MSL (MP2's sanctuary altitude) turned to follow MA1's external lights visually, but did not cross-check available sensors to confirm MA1's position. MP2 did not realize MA1 had executed a complete turn and was headed towards him. MP2 pointed directly at MA1's external lights in an attempt to acquire a visual mode radar lock on MA1. During this time, the distance between aircraft decreased rapidly and MP2 descended from his sanctuary altitude of 16,000 MSL without the requisite situational awareness. MP2 acquired radar lock at 2,500 feet separation but failed to recognize the conflict. At the last moment, both aircraft initiated a left bank away from the other, but their high right wings impacted. Neither MP1 nor MP2 were able to regain control of their aircraft, with both pilots ejecting shortly after impact.

The Accident Investigation Board (AIB) President found by a preponderance of the evidence that the cause of the mishap was MP2's failure to fulfill his primary responsibility to ensure flight path deconfliction and separation of aircraft. Additionally, the AIB President found by a preponderance of the evidence that there were two substantially contributing factors to the mishap: (1) MP1 did not terminate tactical maneuvering following MP2's "Bingo" fuel call and (2) MP1 and MP2 overly relied on visual cues from external aircraft lighting to judge critical flight parameters.

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.

F-16C, T/N 93-0531 and F-16C, T/N 92-3899
LOUISVILLE, GA
7 JUNE 2016

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ACRONYMS AND ABBREVIATIONS

157 FS	157th Fighter Squadron	EMS	Emergency Medical Service
169 FW	169th Fighter Wing	EOR	End of Runway
A/A	Air to Air	EP	Evaluator Pilot
AB	Air Base	FAC-A	Forward Air Controller - Airborne
ACC	Air Combat Command	FAIP	First Assignment Instructor Pilot
ACMI	Air Combat Maneuvering Instrumentation	FCIF	Flight Crew Information Files
admin	administration	FCR	Fire Control Radar
ADO	Assistant Director of Operations	FEF	Flight Evaluation Folder
AF	Air Force	FL	Florida
AFB	Air Force Base	freq	frequency
AFE	Aircrew Flight Equipment	FS	Fighter Squadron
AFI	Air Force Instruction	FW	Fighter Wing
AFRCC	Air Force Rescue Coordination Center	G	Gravitational Force
AFTO	Air Force Technical Order	GA	Georgia
AFTTP	Air Force Tactics Techniques and Procedures	GPS	Global Positioning System
AGL	Above Ground Level	HARM	High-speed Anti-Radiation Missile
AGM	Air to Ground Missile	HFACS	Human Factors Analysis and Classification Systems
AIB	Accident Investigation Board	HUD	Heads-Up Display
AIM	Air to Air Missile	IAW	In Accordance With
AIMWTS	Aeromedical Information Management Waiver Tracking System	IDT	Intraflight Data Transfer
AMRAAM	Advanced Medium Range Air-to-Air Missile	IFF	Introduction to Fighter Fundamentals
ANG	Air National Guard	IMDS	Integrated Maintenance Data System
ARTCC	Atlanta Air Route Traffic Control Center	IP	Instructor Pilot
ATC	Air Traffic Control	IPUG	Instructor Pilot Upgrade
aux	auxiliary	JHMCS	Joint Helmet Mounted Cueing System
AUX	auxiliary	JNGB	Joint National Guard Base
AZ	Arizona	JPRC	Joint Personnel Recovery Center
B course	Basic Course	Jr.	Junior
BD	Battle Damage	KCAS	Knots Calibrated Airspeed
BP	Board President	L	Local Time
BRI	Briefing Room Interactive	LPU	Life Preserver Unit
CAP	Combat Air Patrol	MA	Mishap Aircraft
CAPS	Critical Action Procedures	MAEWR	Mid-Atlantic Electronic Warfare Range
CPM	Crash Protected Memory	ME	Mishap Element
COMM	Communications	MF	Mishap Flight
CSFDR	Crash Survivable Flight Data Recorder	MM	Maintenance Member
CSMU	Crash Survivable Memory Unit	MMC	Modular Mission Computer
DAS	Defense Acquisition System	MOA	Military Operating Area
DAU	Defense Acquisition Unit	MP	Mishap Pilot
D.C.	District of Columbia	MQT	Mission Qualification Training
DED	Data Entry Display	MS	Mississippi
DLO	Desired Learning Objectives	MSL	(Feet) Mean Sea Level
DNIF	Duties Not Involving Flying	nm	Nautical Miles
DO	Director of Operations	NOTAMs	Notices to Airmen
DoD	Department of Defense	NTR	Network Timing Reference
DTC	Data Transfer Cartridge	NV	Nevada
ECSMU	Enhanced Crash Survivable Memory Unit	NVGs	Night Vision Goggles
ELT	Emergency Locator Transmitter	OCA	Offensive Counter Air Operations Group
		OG	

OGV	Operations Group Standardization and Evaluation	ORM	Operational Risk Management
Ops	Operations	OS	Operations Supervisor
Ops Sup	Operations Supervisor	PCS	Permanent Change of Station
Ops Tempo	Operations Tempo	PEX	Patriot Excalibur
OR	Oregon	PH	Phase Inspection
PIT	Pilot Instructor Training	PHA	Periodic Health Assessment
PLF	Parachute Landing Fall	Spatial-D	Spatial Disorientation
PLI	Pre-Launch Inspection	SPINs	Special Instructions
PM	Pilot Member	Stan Eval	Standardization and Evaluation
PR	Pre Flight (Inspection for Maintenance)	TAC	Tactical
PRI	Primary	TACAN	Tactical Air Navigation
PRC	Portable Radio Communicator	TCTO	Time Compliance Technical Order
RESCAP	Rescue Combat Air Patrol	TFI	Total Force Integration
RF	Red Flight	TH	Through-Flight (Inspection for Maintenance)
ROK	Republic of Korea	T/N	Tail Number
RTB	Return to Base	TO	Technical Order
SA	Situational Awareness	TR	Training Rule
SAM	Surface to Air Missile	TX	Texas
SAR	Search and Rescue	UPT	Undergraduate Pilot Training
SC	South Carolina	U.S.	United States
SEAD	Suppression of Enemy Air Defenses	USAF	United States Air Force
SEFE	Standardization and Evaluations Flight Examiner	VA	Virginia
SOF	Supervisor of Flying	VFR	Visual Flight Rules
SMS	Storage Management System	VUL	Vulnerability Period
		WAI	Walk Around Inspection

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 29 August 2016, Major General Jerry D. Harris, Jr., then-Vice Commander, Air Combat Command (ACC), appointed then-Colonel Randal K. Efferson to conduct an aircraft accident investigation board (AIB) of a 7 June 2016 mishap involving two F-16C Fighting Falcon aircraft, tail numbers 92-3899 and 93-0531, which occurred near Louisville, Georgia (GA) (Tab Y-2 to Y-3). The F-16C accident investigation was conducted in accordance with (IAW) Air Force Instruction (AFI) 51-503, *Aerospace and Ground Accident Investigations* at Shaw Air Force Base (AFB), South Carolina (SC) from 8 September 2016 through 8 October 2016 and 5 December 2016 to 9 December 2016 (Tab Y-2 to Y-3). Board members were a Legal Advisor (Major), Pilot Member (Lieutenant Colonel), Medical Member (Captain), Maintenance Member (Technical Sergeant 1), and Recorder (Technical Sergeant 2) (Tab Y-2 to Y-3). An F-16C, Subject Matter Expert (Major) was also appointed to assist in review of cockpit data. (Tab Y-4).

b. Purpose

IAW AFI 51-503, *Aerospace and Ground Accident Investigations*, this accident investigation board conducted a legal investigation to inquire into all the facts and circumstances surrounding this Air Force aerospace accident, prepare a publicly-releasable report, and obtain and preserve all available evidence for use in litigation, claims, disciplinary action, and adverse administrative action (Tab BB-2).

2. ACCIDENT SUMMARY

On 7 June 2016, at approximately 2114 local (L), two F-16C aircraft, tail numbers 92-3899 and 93-0531 (Mishap Aircraft 1 – MA1 and Mishap Aircraft 2 – MA2 respectively), assigned to the 169th Fighter Wing (169 FW), McEntire Joint National Guard Base (JNGB), SC, collided mid-air during a training mission, an opposed night Suppression of Enemy Air Defense (SEAD) sortie (Tab J-5 to J-7). Both pilots (Mishap Pilot 1 – MP1 and Mishap Pilot 2 – MP2, respectively) ejected safely with only minor injuries (Tabs J-5 and X-6 to X-7). Both aircraft impacted the ground near Louisville, GA and were destroyed (Tab J-7). The total aircraft loss is valued at approximately \$60,798,131.00 (Tab P-4). Non-Department of Defense (DoD) property damage was limited to fire damage to cash timber (Tab P-3).

3. BACKGROUND

a. Air Combat Command (ACC)

The mission of ACC is to support global implementation of national security strategy by operating fighter, bomber, reconnaissance, battle management, and electronic-combat aircraft (Tab CC-2 to CC-6). It also provides command, control, communications and intelligence systems and conducts global information operations (Tab CC-2 to CC-6). ACC organizes, trains, equips, and maintains combat-ready forces for rapid deployment and employment while ensuring strategic air defense forces are ready to meet the challenges of peacetime air sovereignty and wartime air defense (Tab CC-2 to CC-6). Additionally, ACC develops strategy, doctrine, concepts, tactics, and procedures for air and space-power employment (Tab CC-2 to CC-6). The command provides conventional and information warfare forces to all unified commands to ensure air, space, and information superiority for warfighters and national decision-makers (Tab CC-2 to CC-6). The command can also be called upon to assist national agencies with intelligence, surveillance, and crisis response capabilities (Tab CC-2 to CC-6). ACC air forces provide the air component to US Central, Southern, and Northern Commands, with Headquarters ACC serving as the air component to Joint Forces Commands (Tab CC-2 to CC-6). ACC also augments forces to US European, Pacific, Africa-based, and Strategic Commands (Tab CC-2 to CC-6).



b. Air National Guard (ANG)

The ANG is administered by the National Guard Bureau, a joint bureau of the departments of the Army and Air Force, located in the Pentagon, Washington, D.C (Tab CC-7 to CC-9). It is one of the seven Reserve components of the United States armed forces that augment the active components in the performance of their missions (Tab CC-7 to CC-9).



The Air National Guard's federal mission is to maintain well-trained, well-equipped units available for prompt mobilization during war and provide assistance during national emergencies, such as natural disasters or civil disturbances (Tab CC-7 to CC-9). During peacetime, the combat-ready units and support units are assigned to most Air Force major commands to carry out missions compatible with training mobilization readiness, humanitarian and contingency operations, such as Operation Enduring Freedom in Afghanistan (Tab CC-7 to CC-9).

c. 9th Air Force (9 AF)

The 9 AF commands, administers and ensures the combat and agile support capabilities of all 9 AF assigned units; conducts a realistic and robust standardization and evaluation program to hone wartime missions and ensure readiness of all assigned active-duty and aligned Air Reserve component units; and identifies advocates for resources required to support 9 AF missions, Airmen and their families (Tab CC-10 to CC-12). The 9 AF vision is to focus the combat/agile support capabilities of all 9 AF units on the current fight, while preparing their



Airmen for the dynamic requirements of air, space and cyberspace in the future (Tab CC-10 to CC-12).

d. 169th Fighter Wing (169 FW)

The mission of the 169 FW is to maintain wartime readiness and the ability to mobilize and deploy expeditiously to carry out tactical air missions or combat support activities in the event of a war or military emergency (Tab CC-13 to CC-15). More specifically, the wing specializes in the Suppression and Destruction of Enemy Air Defenses (Tab CC-13 to CC-15).



e. 157th Fighter Squadron (157 FS)

The mission of the 157 FS, in alignment with the 169 FW, is to maintain wartime readiness and the ability to mobilize and depoly expeditiously to carry out tactical air missions or combat support activities in the event of a war or military emergency (Tab CC-13 to CC-15). More specifically, the wing specializes in the Suppression and Destruction of Enemy Air Defenses (Tab CC-13 to Tab CC-15).



f. F-16C Fighting Falcon



The F-16C Fighting Falcon is a compact, multi-role fighter aircraft (Tab CC-16 to CC-19). It is highly maneuverable and is proven in air-to-air combat and air-to-surface attack (Tab CC-16 to CC-19). It provides a relatively low-cost, high performance weapon system for the United States (US) and allied nations (Tab CC-16 to CC-19).

In an air combat role, the F-16's maneuverability and combat radius (distance it can fly to enter air combat, stay, fight and return) exceed that of all potential threat fighter aircraft (Tab CC-16 to CC-19). It can locate targets in all weather conditions and detect low flying aircraft in radar ground clutter (Tab CC-16 to CC-19). In an air-to-surface role, the F-16 can fly more than 500 miles (860 kilometers), deliver its weapons with superior accuracy, defend itself against enemy aircraft, and return to its starting point (Tab CC-16 to CC-19). An all-weather capability allows it to accurately deliver ordnance during non-visual bombing conditions (Tab CC-16 to CC-19).

4. SEQUENCE OF EVENTS

a. Mission

On 7 June 2016, the Mishap Flight (MF), call sign Mace 31 (MP1), Mace 32 (MP2), Mace 33 (Mishap Element 3 – ME3), and Mace 34 (Mishap Element 4 – ME4) performed an Offensive Counter-Air (OCA) SEAD Instructor Pilot Upgrade mission for MP1 with Viper 41 (Red Flight 1 – RF1) and Viper 42 (Red Flight 2 – RF2) as adversaries/strikers as authorized by the 157 FS (Tab K-2 to K-3). The training mission was conducted in Bulldog Military Operating Area (MOA), located in Georgia, approximately 100 nautical miles (nm) southwest of McEntire JNGB, SC (Tabs W-2 and AA-4). The MF was scheduled to depart McEntire JNGB at 2015L and return at 2145L (Tab K-2 to K-3).

b. Planning

MP1 and MP2 planned the mission on 6 June 2016 by developing the sortie scenario, desired learning objectives (DLOs), training objectives for MP1, and mission materials (Tabs R-5, R-14, V-1.2 to V-1.3, V-1.14, and V-2.4). On the afternoon of 7 June 2016 (approximately two hours prior to planned takeoff time), there was a coordination brief, which was attended by all four pilots of the MF and two pilots of Red Flight (RF) (Tab V-1.4). The briefing was conducted IAW 157 FS standards utilizing Briefing Room Interactive (BRI – an electronic briefing medium), dry-erase board notes and diagrams, and the 169 FW pilot aid (Tab V-4.2 to V-4.3 and V-8.2 to V-8.3). MP1 conducted the coordination and MF briefs, which covered weather, Notices to Airmen (NOTAMs), Operational Risk Management (ORM), emergency procedures, personal equipment, ground operations, takeoff/departure, working area, training rules, aircraft deconfliction, mission scenario/priorities, alternate missions/events, and Return To Base (RTB) IAW AFI 11-2F-16.v3 (Tabs K-11, V-4.2, V-8.2, and BB-26).

The briefed SEAD plan was for the MF to conduct two training scenarios (“Offensive Counter Air Suppression of Enemy Air Defense Vulnerability Period (OCA SEAD VUL)”) in the Bulldog MOA. (Tabs K-11 and V-4.5) The second scenario (in which the mishap occurred) was for the MF to conduct SEAD operations from a geographically-fixed Combat Air Patrol (CAP) location oriented toward a target area (Tabs V-4.5 and AA-5). In this scenario, RF would act as adversary air and then re-role as friendly strikers that would ingress and egress the target area (Tabs V-1.4, V-4.5, and AA-5).

(1) Formation Planning

In the training scenarios, MA1 and MA2 planned to operate in a visual wedge formation, as delineated in Air Force Tactics, Techniques, and Procedures 3-3.F-16 (Tabs V-1.7, V-2.9, BB-41 to BB-54), with MA2 (wingman and instructor pilot of record) trailing MA1 (Tab V-1.7). The primary method of deconfliction was visual, with secondary being sensor (air-to-air (A/A) Tactical Air Navigation (TACAN)) (Tab V-1.7).

The use of night vision goggles (NVG) was considered in planning for the second scenario (Tab V-1.3). Due to the ambient light, MP1 made a decision, between scenarios, to not use NVGs (Tabs B-54, V-1.3, V-1.6, and V-1.7). MP2 did not use the NVGs, except briefly to assess environmental conditions between scenarios (Tab V-2.2, V-2.5).

Visual formation parameters are limited to a maximum of 3 nautical miles(nm), because it is too difficult to discern whether a flight lead is turning left/right or pointing towards/away. (Tab BB-44 and BB-50). If exceeding 3 nm, the wingman is required to make a radio (stripped) call, which would apprise that the wingman was outside the proper formation position. (Tabs V-1.8 and BB-44).

In sensor formations (over 3 nm), distance ranges are expected to naturally collapse during turns and wingmen are required to delay turns to maintain spacing (Tab BB-46). Consequently, wingmen are required to use all available tools to confirm deconfliction (Tab BB-44). MP1 and MP2 only had the Fire Control Radar (FCR) and A/A TACAN to monitor formation positions. (Tab V-1.5 and V-1.12). Link-16 systems were not operable (Tab V-1.6 and V-2.5).

The Wingman/trailing element is responsible for flight path deconfliction (Tab BB-29). MP2 relayed that his primary method of deconfliction was to “just [keep] sight of [MP1]” (Tab V-2.6). Wingmen are required to strive to maintain altitude stack (separation) at all times in sensor formations (Tab BB-29). MF had different assigned (sanctuary) altitudes to ensure altitude separation during the tactical maneuvers (Tab V-1.4). MA1’s sanctuary altitude was 15,000 feet mean sea level (MSL); MA2’s sanctuary altitude was 16,000 MSL (Tab V-1.4).

(2) Termination Planning

Tactical maneuvering (scenario) would continue until the DLO were accomplished, with MP1 providing a “Terminate” or “Knock It Off” call (Tabs V-1.15 and BB-7). Any member could, however, call “Knock It Off”, even prior to completion of the DLO. (Tab BB-7). A “Knock It Off” call would then require all members of the MF to cease the training tactical maneuvering and initiate administrative maneuvering (non-scenario, rejoining the flight into an approved formation to transit between operating area and home base) (Tab BB-7).

Additionally, if any aircraft reached a predetermined, low fuel state, the respective pilot would be required to provide a “Bingo” radio call. (Tab BB-7). “Bingo” is a pre-briefed fuel state that, when reached, requires termination of tactical maneuvering and return to base with normal recovery fuel (Tab BB-9). MP1 would be required to acknowledge and either provide a “Knock

It Off” call (terminating tactical maneuvering) or “reset Bingo” (permitting tactical maneuvering until reaching the reset fuel level) (Tabs V-1.15 and BB-7).

c. Preflight

Following MF and RF briefs, all pilots donned flying gear, retrieved classified materials, and gathered at the operations desk for a briefing, often referred to as a “step brief,” from the Operations Supervisor (OS) (Tab V-4.3 and V-8.3). The step brief included updates to local airfield status, applicable Flight Crew Information Files (FCIF), individual training requirements, aircraft status and configuration, spare aircraft status, weather, NOTAMs, and ORM review (Tab V-4.3 to V-4.4, V-8.3, and V-10.2 to V-10.3). MF and RF confirmed their flight plans with operations desk personnel who, in turn, filed the flight plans electronically (Tabs K-3 to K-4, AA-6). After the step brief, pilots walked to their respective aircraft, reviewed aircraft forms, performed a preflight inspection, started engines, and completed standard aircraft checklists (Tab V-4.4, V-8.3, and V-10.3).

d. Summary of Accident

(1) Prior to Scenario

Engine start, taxi, and arming the aircraft were all uneventful for both MF and RF (Tab V-4.4, V-8.3, and V-10.3). MF performed afterburner takeoffs at 2015L with 15-second spacing between aircraft and rejoined to a 2+2 formation with one nm spacing between elements (Tab V-4.4). RF performed the same takeoff sequence at 2018L and performed a visual rejoin to wedge formation (Tab V-4.4 and V-8.4). There was nothing of note with Air Traffic Control (ATC) instructions, routing, or weather during the departure to the MOA for either MF or RF (Tab V-1.1 to V-10.3).

MF entered Bulldog MOA at 20:28:30L, followed by RF (Tab GG-4 to GG-6). MF and RF performed separate G-awareness (a turning exercise to determine the pilots’ tolerance of gravitational forces) exercises prior to beginning the first scenario (Tab V-1.16, V-4.5, and V-8.4). Following G-awareness maneuvers, MP1 directed MP2 and ME4 to fly fighting wing formation off flight leads and directed ME3 to one nautical mile trail formation (Tab GG-4 to GG-6).

(2) First Scenario

The first scenario began at 20:35:12L (Tab GG-4 to GG-6). It lasted approximately twenty minutes and included multiple air-to-air engagements as well as multiple Surface-to-Air Missile (SAM) engagements (Tab GG-4 to GG-6). The first scenario was uneventful with the exception of MP2 calling blind (lost visual contact) (Tabs V-1.9, and GG-4 to GG-6). No training rule violations were noted (Tab V-1.4 and V-2.5). The first scenario ended with the accomplishment of established DLOs and a “Knock it off” call by MP1 at 20:54:50L (Tab GG-4 to GG-6).

(3) Second (Mishap) Scenario

The second scenario began at approximately 21:00:00L (Tab GG-4 to GG-6). MF executed the scenario in a spread four formation and the SEAD engagement with MP2 and ME4 in a visual wedge formation (Tab V-1.7 to V-1.8, V-2.5 to V-2.11, V-3.3 to V-3.4, and V-5.4 to V-5.7). MF prosecuted multiple red air presentations and SAM engagements prior to the mishap (Tab GG-4 to GG-6).

At 21:07:03L, MF began a SAM engagement requiring numerous threat avoidance maneuvers, resulting in MP1 and MP2 exceeding the planned visual wedge formation (Tab GG-4 to GG-6). MP2 lost visual contact with MA1 at 21:09:03L and called blind (“One, say your bullseye, two’s blind”) (Tab GG-4 to GG-6). MP1 responded with heading information (“One’s at 15, bullseye 209 for 27”) (Tab GG-4 to GG-6). At 21:12:07L, MP2 made another blind call (“Two’s still blind at sixteen one, give me a flare”) (Tab N-2) and 5.2 nm separation (Tab V-2.6 and GG-4 to GG-6). Following MP2’s visual acquisition of MP1’s flare (Tab V-2.6), MP2 acknowledged (“One press”) (Tab N-2), and MP1 relayed heading information for his next SAM engagement (“One’s engaged, One’s heading three zero zero”) (Tab N-2). At 21:12:58L, the distance range between MA1 and MA2 decreased to 3.2 nm (Tab GG-4 to GG-6).

At 21:13:19L, ME3 and ME4 had communicated their impending attack on a SAM (Tab N-2). At 21:13:23L, MP2 made a “Bingo” fuel call (“Two’s Bingo”) (Tab N-2). Four seconds later, MP1 acknowledged the call (“Copy Bingo”) and began a sharp left turn at 15,200 MSL (Tabs N-2 and Z-8). MP1 did not communicate the left turn. (Tab N-2). MP2’s aircraft position was 3.8 nm behind MP1 at 15,640 MSL (Tab GG-4 to GG-6).

At 21:13:38L, MP1 intended a communication for MP2, but incorrectly stated, “Four, you can continue north”, to which ME4 confirmed that he was attacking a northern SAM (Tab N-2, V-5.8, V-5.14, and GG-4 to GG-6).

Approximately five seconds later, MP2 began attempts (the first of nine attempts) to obtain a fire control radar (FCR) boresight lock on MA1 (Tab GG-4 to GG-6). The FCR boresight lock is utilized for targeting but would provide limited information on the other aircraft, including bearing and altitude. (Tab Z-30).

At 21:13:47L, MP1 continued his sharp left turn and corrected his incorrect call (“Sorry, two continue north”), which MP2 acknowledged (“Copy that”) (Tab N-2). MP2 continued maneuvering visually with MA1 in a southwest direction (Tab V-2.11). MP2 assessed MA1’s line of sight from right to left, incorrectly perceiving that MA1 was in a slight left turn, heading away from MP2 (Tab V-2.11). MP2 believed the MF would eventually turn north together (Tab V-2.9 to V-2.13).

At approximately 21:13:50L, MP1 had completed his turn, was heading northeast at 15,290 MSL, and attempted an FCR boresight lock on MA2 (Tab V-1.12, GG-4 to GG-6).

At approximately 21:13:57L (six seconds to impact), MP2 achieved a boresight lock on MA1, as confirmed by removable media cartridges, but MP2 did not recall intentionally taking a boresight

lock (Tabs V-2.12 and GG-4 to GG-6). The boresight lock indicated an initial range of 2,500 feet that decreased almost immediately to 1,400 feet between aircraft (Tab Z-30 to Z-31). The heads up display (HUD) provided “Break-X symbology”, indicating that the two aircraft were approaching head-on. (Tabs Z-30 to Z-31, GG-4 to GG-6). Prior to impact, MP2’s last assessed heading was 234 degrees (southwest) and 15,300 MSL (Tabs J-5, J-22 and Z-31).

At 21:13:58L (five seconds to impact), MP1 achieved a boresight lock on MA2, which indicated an initial range of 5,700 feet that decreased almost immediately to 3,700 feet between aircraft, with Break-X symbology in the HUD (Tabs Z-16 and GG-4 to GG-6). At 21:14:02, MP1’s last recorded HUD data indicated a heading of 054 degrees, 15,290 MSL, and a range of 1,300 feet between aircraft with Break-X symbology in the HUD (Tabs Z-17, Z-32 and Z-33).

MA1 and MA2 flight controls first revealed significant control inputs approximately one second prior to the mishap (Tab J-17 and J-22).

Figure 1a: Time Sequence of events from 21:13:23 (MP2 “Bingo” call) to 21:13:48



(Tab Z-32)

Figure 1b: Time sequence of events from 21:13:49 to 21:14:03 (Impact)



(Tab Z-33)

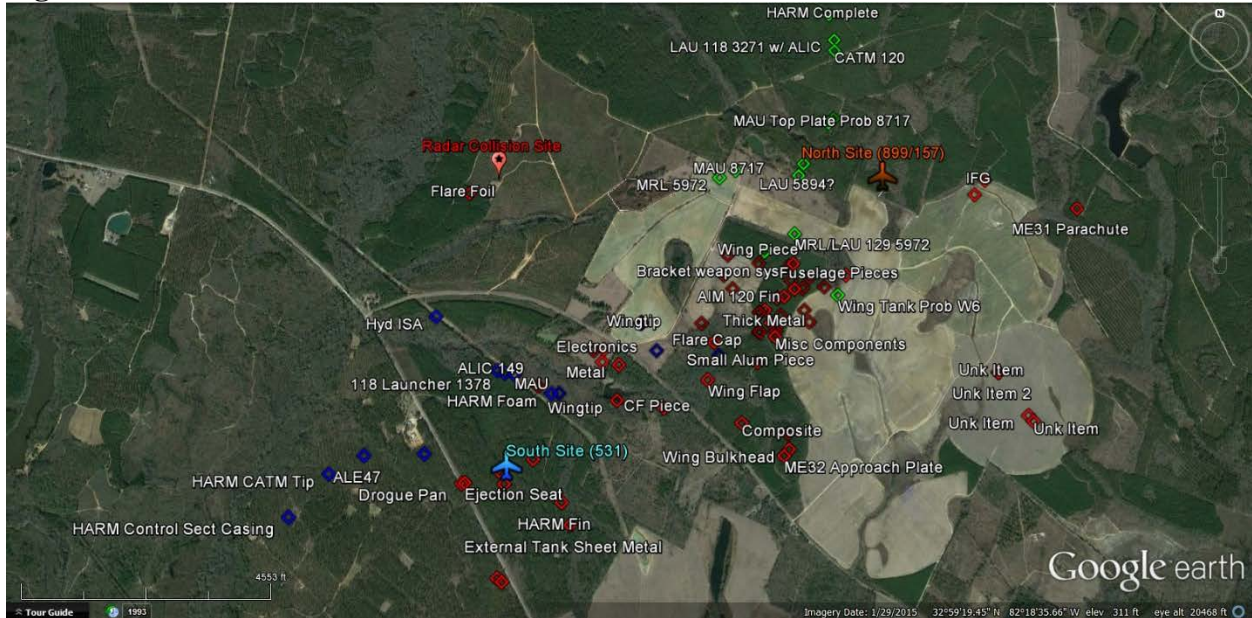
Lockheed Martin Aeronautics Company’s Technical Report assessed the probable collision altitude between approximately 15,245 MSL and 15,282 MSL (Tab J-17 and J-22).

e. Impact

At 21:14:03L, MP1 and MP2 collided approximately 110 nm southwest of McEntire JNGB, SC, and east of Louisville, GA, in the Bulldog MOA (Tab J-7). At impact, MP1’s aircraft was heading 054 degrees (Tabs J-5 and Z-17), 20.4 degrees left wing down, 7.4 degrees nose up, and 327 knots calibrated air speed (KCAS) (Tab J-17). MP2’s aircraft was heading 234 degrees (Tab J-5), 11.9 degrees left wing down, 5.0 degrees nose up, and 257 KCAS (Tab J-22).

There were two primary crash sites located approximately 1.7 nm apart with the majority of aircraft debris contained at the individual crash sites (Tab J-7). Crash recovery teams located debris over an approximately four square mile area (Tab J-7).

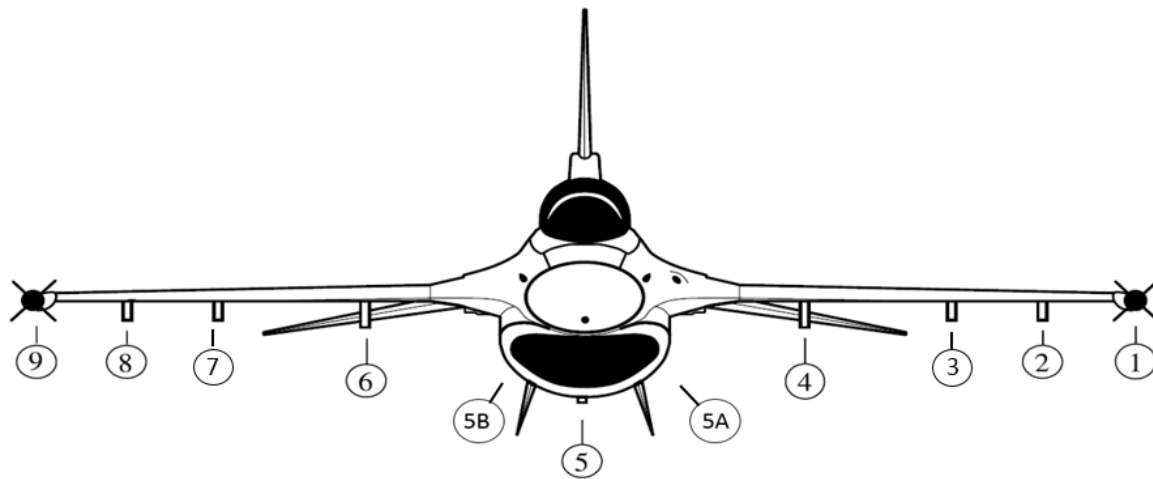
Figure 2: MA1 and MA2 crash sites and debris field



(Tab S-8)

The leading edge of MA2's right wing exhibited a blunt force indentation in an upward direction near station seven (Tab J-12). There was insufficient physical evidence to conclusively determine impact geometry on MA1 (Tab Z-34).

Figure 3: MA1's and MA2's mishap sortie configuration: MA1 impact near Station 7; MA2 impact undetermined. (Tab J-12)



MP1 and MP2's aircraft were similarly configured (Tabs K-5 to K-10, and J-6). For reference, the numbers in Figure 3 above correspond to the following station numbers:

- Station 1: AIM-120B
- Station 2: ACMI Pod
- Station 3: AGM-88C
- Station 4: 370 Gallon Fuel Tank and 16S1300 Pylon
- Station 5A: HARM Targeting System
- Station 5: Empty
- Station 5B: Sniper Pod
- Station 6: 370 Gallon Fuel Tank and 16S1300 Pylon
- Station 7: AGM-88C
- Station 8: AIM-9X
- Station 9: AIM-120C

(Tabs K-5 to K-10, and J-6)

Figure 4: MA2's right wingtip with upward blunt force indentation



(Tab J-12)

f. Egress and Aircrew Flight Equipment (AFE)

Egress and Aircrew Flight Equipment functioned correctly, without discrepancy.

(1) MP1

Twelve seconds after collision, at 21:14:15L and 14,975 MSL, MP1 initiated a radio call, “Knock it off, Mace one emergency, out of control. Passing fourteen thousand” (Tab J-17). As MP1 attempted to regain control of his aircraft, he made another radio call at 21:14:40L and 9,560 MSL, “Mace one cannot get it back under control” (Tab J-17). Approximately two seconds later, at 21:14:42L and 8,722 MSL, MP1 made a third radio call, “Passing through nine thousand” (Tab J-17). At 21:14:54L and 6,275 MSL, MP1 made his last airborne radio call, “Mace one is ejecting” (Tab J-18).

MA1's parameters at the time of MP1's ejection, at 21:14:56L, were 5,562 MSL (approximately 5,312 feet above ground level (AGL); crash site elevations are approximately 250 MSL) (Tab J-17 and J-18), unconfirmed airspeed (Crash Survivable Flight Data Recorder, or CSFDR, data indicated unreliable airspeed values), 3.2 degrees nose up, and 42.6 degrees right wing down (Tab J-18). MP1 initiated a successful ejection with correct sequencing, man-seat separation, and proper parachute deployment with an intact canopy (Tab V-1.16 to V-1.17).

All required AFE inspections were current and MP1 was wearing the appropriate life support equipment for the mission (Tab H-3 to H-5). MP1's AFE items were inspected post mishap and all components were in working condition with the exception of the PRC-90 radio due to a dead

battery at the time of inspection (Tab H-4 to H-5). However, MP1's testimony indicates the PRC-90 was operable following the mishap (Tab V-1.17).

(2) MP2

Eight seconds after collision, at 21:14:11L and 15,315 MSL, MP2 initiated a radio call, "Knock it off boys, knock it off" (Tab J-22).

MA2's parameters at the time of MP2's ejection, at 21:14:24L, were 14,325 MSL (approximately 14,075 AGL) (Tab J-7 and J-22), unconfirmed airspeed (CSFDR data indicated unreliable airspeed values), 9.8 degrees nose up, and 0.1 degrees right wing down (Tab J-22). MP2 initiated a successful ejection within recommended parameters for an uncontrolled ejection (greater than 6,000 AGL) with correct sequencing, man-seat separation, and proper parachute deployment with an intact canopy (Tab V-2.14).

All required AFE inspections were current and MP2 was wearing appropriate equipment for the mission (Tab H-6 to H-7). MP2's AFE items were inspected post mishap and all components were in working condition with the exception of the PRC-90 radio due to a dead battery at the time of inspection (Tab H-6 to H-7). However, MP2's testimony indicates the PRC-90 was operable following the mishap (Tab V-2.15 to V-2.16).

g. Search and Rescue (SAR)

Following the initial impact of MA1 and MA2 at 21:14:03L, MP2 was the first pilot to initiate ejection at 21:14:24L (Tab J-22). MP1 subsequently initiated ejection at 21:14:56L (Tab J-18). At 2114L, the Air Force Rescue Coordination Center received satellite notification that two military distress signals were activated (Tab H-3).

At the time of the mishap, ME3, ME4, RF1, and RF2 were operating within the confines of the Bulldog MOA and initiated a "Knock it off" call (Tab V-3.9). ME3 assumed duties of initial on-scene commander and directed geographic deconfliction points and altitudes for the remaining aircraft (Tab V-3.9 and V-5.13). RF2 and ME4 eventually located both downed Airmen with their targeting pods and passed coordinates to ME3 (Tab V-3.9 to V-3.10 and V-5.13). ME3 continued coordination with ME4 and RF2 in an attempt to communicate with and ascertain the status of MP1 and MP2 while RF1 provided radio relay to McEntire JNGB and Atlanta Air Route Traffic Control Center regarding the status of the MPs and coordination for additional SAR assets (Tab V-3.9 to V-3.10). At 2126L, the McEntire Supervisor Of Flying (SOF) received notification from RF1 of the mid-air collision between MP1 and MP2 (Tab GG-4 to GG-6). The SOF utilized Google Earth to plot the MPs' positions received from RF1 and notified the Jefferson County, Georgia Sheriff's Department via telephone at annotated time 2130L (Tabs GG-4 to GG-6 and V-9.8). During this time, ME4 and RF1 had to RTB due to low fuel (Tab V-3.10). ME3 and RF2 were able to establish two-way communication with MP2 and subsequently MP1, and verified that neither suffered serious injury and both were ambulatory (Tab V-3.10 and V-7.7). Following positive communication with both MPs, ME3 and RF2 returned to base due to low fuel (Tab V-3.10).

During ME3's RTB, he coordinated with Stalk 51 (F-16 from McEntire JNGB) flight who was conducting a practice scramble and then diverted by the SOF to Bulldog MOA to assist as on-scene commander (Tab V-3.10 and V-5.13). At 2152L, MP2 utilized a cell phone borrowed from a nearby house to contact the McEntire SOF to relay his condition and provide an address for pickup (Tabs V-2.15 to V-2.16 and FF-16). Stalk flight assumed on-scene commander duties at 2153L (Tab FF-16). Local emergency medical services (EMS) retrieved MP2 at the address he provided, and he utilized his PRC-90 radio while riding in the ambulance to assist SAR assets in locating MP1 (Tab V-1.17 to V-1.18 and V-2.16). Stalk flight was replaced by Bengal 43 (Tab GG-2) at 2200L (Tab GG-2). Bengal 43 responded and located MP1 and provided directions for MP1 to walk toward a road intersection to assist in his recovery (Tabs V-1.17 to V-1.18 and GG-2). During his walk to the intersection, MP1 heard voices in vicinity of where he left his parachute, changed direction and walked toward the voices and was recovered by local volunteer fire fighters (Tab V-1.18). Following MP1's recovery, Jefferson County law enforcement notified the McEntire SOF that both MPs were uninjured and transported both MPs to the Jefferson County, GA hospital for evaluation and treatment (Tab FF-5 to FF-6). King 21 loitered and provided on-scene commander duties until both MPs were retrieved by local law enforcement and EMS (Tab V-2.16).

h. Recovery of Remains

Not applicable

5. MAINTENANCE

a. Forms Documentation

The Air Force Technical Order (AFTO) 781 series forms collectively document maintenance actions, inspections, servicing, configuration, status, and flight activities for the maintained aircraft (Tab BB-18). The Integrated Maintenance Data System (IMDS) is an electronic database used to track maintenance actions, flight activity, and to schedule future maintenance (Tab BB-11 and BB-12).

Review of the active 781 forms and IMDS revealed no overdue inspections or open Time Compliance Technical Orders that would ground MA1 or MA2 from flight operations (Tabs D-4 to D-39 and U-6 to U-401). There is no evidence to suggest forms documentation was a factor in the mishap (Tabs D-4 to D-39 and U-6 to U-401). Review of IMDS data for MA1 covering a 68-day period and MA2 covering a 38-day period prior to the mishap revealed maintenance documentation was properly accomplished under applicable maintenance directives (Tab U-45 to U-196, U-256 to U-339, and U-402 to U-406).

b. Inspections

The Pre-Flight Inspection (PR) includes visually examining the aircraft and operationally checking certain systems and components to ensure no serious defects or malfunctions exist (Tabs BB-14 to BB-15). The Thru-Flight Inspection (TH) is completed between flights and is accomplished after each flight when a turnaround sortie or a continuation flight is scheduled (Tab BB-15). Phase

inspections (PH) are a thorough inspection of the entire aircraft (Tab BB-16). Walk-Around Inspections (WAI) or Pre-Launch Inspections (PLI) are abbreviated pre-flights and are completed prior to launch IAW the applicable Technical Order (TO) (Tab BB-14 and BB-15).

The total airframe operating time of MA1 at takeoff of the mishap sortie was 6029.7 hours (Tab D-2 and D-4). MA1 had flown 248.4 hours since the last PH, which was completed on 23 March 2015 (Tab U-2). The last PR occurred on 6 June 2016 at 1200L, with no discrepancies noted (Tab D-4). The day of the mishap a WAI was performed at 1430L, and a follow-up TH was performed at 1850L, showing only one unscheduled discrepancy that was unrelated to the mishap (Tab D-6 to D-16).

The total airframe operating time of MA2 at takeoff of the mishap sortie was 5667.3 hours (Tab D-3 and D-22). MA2 had flown 89.8 hours since the last PH, which was completed on 22 March 2016 (Tab U-3). The last PR occurred on 6 June 2016 at 1140L, with no discrepancies noted (Tab D-22). The day of the mishap a WAI was performed at 1400L, and a follow-up TH was performed

c. Maintenance Procedures

A review of MA1's and MA2's AFTO 781 series forms and IMDS revealed all maintenance actions complied with standard approved maintenance procedures and TOs (Tab BB-11 to BB-12 and BB-18). There is no evidence to suggest maintenance procedures were a factor in the mishap (Tab U-402 to U-406).

d. Maintenance Personnel and Supervision

The 169th Aircraft Maintenance Squadron personnel performed all required inspections, documentation, and servicing of MA1 and MA2 prior to flight (Tab D-4 to D-39). A detailed review of maintenance activities and documentation revealed no major documentation errors (Tab D-4 to D-39). Personnel involved with MA1's and MA2's preparation for flight had adequate training, experience, expertise, and supervision to perform their assigned tasks (Tab T-5 to T-73). There is no evidence to suggest that maintenance personnel and supervision were a factor in this mishap (Tabs D-4 to D-39, T-5 to T-73, and X-6 to X-7).

e. Fuel, Hydraulic, and Oil Inspection Analyses

Prior to the mishap flight, engine Joint Oil Analysis Program samples were taken on 7 June 2016 and analyzed by the 169th Maintenance Squadron (Non-Destructive Inspection Unit) (Tab U-4 to U-5). The samples were free of any contamination (Tab U-4 to U-5). There is no evidence to suggest fuel, hydraulic, or oil quality were factors in the mishap (Tab D-5).

f. Unscheduled Maintenance

The AIB conducted a review of unscheduled maintenance events for MA1 and MA2 for the previous 68 days and 38 days respectively (Tabs D-6 to D-16, D-23 to D-34, U-45 to U-196, U-256 to U-339, and U-402 to U-406). MA1 had three different unscheduled discrepancies and MA2 had four that had been documented and addressed within the active forms prior to the mishap flight

(Tab D-11, D-15, D-26 to D-27, and D-33 to D-34). These discrepancies were not contributing factors to the mishap (Tab D-11, D-15, D-26 to D-27, and D-33 to D-34).

Exceptional Releases for both MA1 and MA2 were completed and the aircraft deemed airworthy by the acting or career production supervisor (Tab D-4 and D-22). The Exceptional Release serves as a certification that the signing supervisor has reviewed the active forms to ensure the aerospace vehicle is safe for flight (Tab BB-17). There is no evidence to suggest that unscheduled maintenance was a factor in this mishap (Tab D-4 and D-22).

6. AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS

a. Structures and Systems

(1) MA1 Condition

MA1 received damage during the midair collision to its right leading edge flap, the right outboard wing, the outboard flaperon, and the right horizontal stabilizer (Tab J-37). MA1 upon impact broke into two sections near the Fuselage Station 341 just forward of the installed engine (Tab J-7). Post impact analysis deemed MA1 a total loss (Tabs J-5 and P-4).

Figure 5: F-16C damaged parts breakdown



(Tab Z-2)

(2) MA2 Condition

MA2 received damage during the midair collision to its right leading edge flap and the right inboard wing (Tab J-11 to J-12). MA2 sustained damage to all flight control surfaces detaching them from the fuselage upon ground impact (Tab J-9). There was evidence of post-impact fire at

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the crash site involving the fuselage, engine, and the right horizontal tail (Tab J-9). A portion of the outboard right wing was detached during the midair collision (Tab J-11). Post impact analysis deemed MA2 a total loss (Tabs J-5 and P-4).

b. Evaluation and Analysis

Analysis conducted by Lockheed Martin Aeronautics Company utilized data from both MA1's and MA2's Crash Survivable Flight Data Recorder, Data Acquisition Unit, and the Enhanced Crash Survivable Memory Unit (Tab J-12 to J-24). Post-crash analysis revealed flight control surfaces, engine, electrical, and hydraulic systems were performing as expected prior to mishap (Tab J-33 and J-35 to J-38). MA1 and MA2 had no relevant reportable maintenance issues prior to the mishap (Tab D-6 to D-16 and D-23 to D-34). There is no evidence to suggest that either aircraft maintenance or aircraft maintenance documentation were factors in this mishap (Tabs D-4 to D-39 and U-45 to U-406).

7. WEATHER

a. Forecast Weather

The 169 FW weather flight provided the mission execution forecast valid from 2000-2300L on 7 June 2016 (Tab F-2 to F-6 and F-12 to F-13). The forecast included sunset at 2033L, civil twilight ending at 2105L, and moonrise at 2051L (Tabs F-2 and W-6) and high solar/lunar illumination at 480.24 millilux (Tabs F-13 and BB-8). McEntire JNGB forecasted weather conditions for takeoff and landing were winds from the west at nine knots with seven miles visibility, clouds scattered at 5,000 AGL and local altimeter setting of 29.70 inches of mercury (Tab F-2). The Bulldog MOA forecast specified winds from the northwest at nine knots with seven miles visibility, clouds scattered from 5,000-8,000 AGL and local altimeter setting of 29.72 inches of mercury (Tab F-3). There was no forecasted precipitation for either McEntire JNGB or Bulldog MOA (Tab F-2 to F-6).

b. Observed Weather

The observed weather at Kaolin Field in Sandersville, GA (approximately 30 miles west of the crash site and located within the confines of Bulldog MOA) at 0115L was winds calm with 10 miles visibility and clouds scattered at 8,500 AGL and local altimeter setting of 29.77 inches of mercury (Tabs W-3 and F-9). MP2 reported visual conditions as challenging due to sunset with increased sky glow in the west and dark skies in the east (Tabs W-4 to W-5, V-2.5, and V-2.9). The weather post-mishap did not change (Tab F-8 to F-9).

c. Space

Not applicable.

d. Operations

No evidence was found to suggest that either of the mishap aircraft was operating outside its prescribed operational limits with respect to weather.

8. CREW QUALIFICATIONS

a. Mishap Pilot 1 (MP1)

MP1 was a current and qualified active duty Instructor Pilot (IP) in the F-16C (Tab G-4 to G-22, G-44, and G-49 to G-50). MP1 was initially qualified in the F-16 in 2000 and has completed the following courses: Undergraduate Pilot Training (UPT), and the Introduction to Fighter Fundamentals (IFF) course (Tab T-74 and T-129 to T-130). MP1 had 1961.9 hours in the F-16 (Tab G-4).

MP1’s recent flight time was as follows on the day of the mishap (Tab G-6):

MP1	Hours	Sorties
Last 30 Days	6.8	5
Last 60 Days	19.6	13
Last 90 Days	30.3	21

c. Mishap Pilot 2 (MP2)

MP2 was a current and qualified IP and Evaluator Pilot in the F-16C (Tab G-23 to G-43, G-55 and G-59). MP2 was initially qualified in the F-16 in 2005 and has completed the following courses: UPT, T-37 Pilot Instructor Training (PIT), and IFF (Tabs G-55, T-132, T-165, T-194 to T-195). MP2 had 1677.6 hours in the F-16 (Tab G-25).

MP2’s recent flight time was as follows on the day of the mishap (Tab G-27):

MP2	Hours	Sorties
Last 30 Days	12.0	8
Last 60 Days	23.7	16
Last 90 Days	36.2	26

9. MEDICAL

a. Qualifications

MP1 was medically qualified for flying duties at the time of the mishap (Tab X-6 to X-7). He had an unremarkable Periodic Health Assessment (PHA) on 11 May 2016 (Tab X-2 to X-3).
F-16C, T/N 93-0531 and F-16C, T/N 92-3899, 7 June 2016

Comprehensive review of his medical records revealed MP1 had no acute or chronic medical issues that required an aeromedical flying waiver (Tab X-6 to X-7). A search of the Aeromedical Information Management Waiver Tracking System (AIMWTS) database revealed no prior waivers (Tab X-2 and X-6).

MP2 was also medically qualified for flying duties at the time of the mishap (Tab X-6). He had an unremarkable PHA 14 May 2016 (Tab X-2 and X-4). Comprehensive review of his medical records indicated that MP2 had no acute or chronic medical issues that required an aeromedical waiver (Tab X-6 to X-7). A search of the AIMWTS database revealed no prior waivers (Tab X-2 and X-7).

b. Health

MP1 successfully ejected from his aircraft approximately 53 seconds following collision (Tab J-5 and J-17 to J-18). He suffered some minor superficial skin injuries following emergency egress (Tab X-6 to X-7). Post-mishap emergency room evaluation, post-mishap flight surgeon exam, 72-hour and 14-day histories collected the night of the mishap demonstrated no performance-limiting illness (Tabs R-2 to R-11 and X-6 to X-7). MP1 was in good overall health and no contributory medical findings were reported (Tab X-6 to X-7).

MP2 successfully ejected from his aircraft approximately 21 seconds following the collision (Tab J-5 and J-22). He suffered minor skin lacerations following emergency egress (Tab X-6 to X-7). Post-mishap emergency room evaluation, post-mishap flight surgeon exam, and 72-hour history collected the night of the mishap demonstrated no performance-limiting illness (Tabs R-12 to R-22 and X-6 to X-7). His 14-day history was significant for use of an over-the-counter decongestant and antihistamine between five and seven days prior to the mishap while on leave (Tabs R-21 and X-6 to X-7). While use of these medications was not reported to a flight surgeon for an aeromedical disposition as required per medical standards, two objective clinical examinations by the treating emergency room physician and flight surgeon performed the night of the mishap revealed no significant performance limiting illness (Tabs X-6 to X-7 and BB-5). MP2 was in good overall health and no contributory medical findings were reported (Tab X-6 to X-7).

72-hour and 14-day histories for four maintenance members collected the night of the mishap were also reviewed (Tab X-6 to X-7). There was no evidence to suggest that the personal health of the maintainers was a factor in this mishap (Tab X-6 to X-7).

c. Pathology

The Armed Forces Medical Examiner System tested blood and urine samples for both MP1 and MP2 IAW AFI 91-204, *Safety Investigations and Reports* (Tab BB-20 to BB-21). Blood and urine samples are used to measure carbon monoxide levels, blood alcohol screening, and toxicology (amphetamines, barbiturates, benzodiazepines, cannabinoids, cocaine, opioids, phencyclidine, and sympathomimetic amines) in urine (Tab X-6 to X-7). All results from the two mishap pilots were negative or otherwise unremarkable (Tab X-6 to X-7). Maintainers were not tested (Tab X-6 to X-7).

d. Lifestyle

There was no evidence to suggest that the lifestyle factors of MP1, MP2, or the maintenance members were a factor in the mishap (Tabs R-2 to R-22 and X-6 to X-7).

e. Crew Rest and Crew Duty Time

IAW AFI 11-202 Volume 3, *General Flight Rules*, aircrew members are required to receive a minimum of 12 non-duty hours of crew rest prior to performing flight duty (Tab BB-33). They are authorized to take meals, rest, and transport (Tab BB-33). They must be afforded an opportunity for at least eight hours of uninterrupted sleep (Tab BB-33). Official crew rest period cannot begin until after completion of official duties (Tab BB-33).

A review of MP1's and MP2's duty cycles leading up to the mishap based on 72-hour and 14-day histories indicated that they received adequate crew rest time (Tabs R-2 to R-22 and X-6 to X-7). MP2 had recently returned from leave and his sleep cycles were adequate for mission participation following post-mishap Fatigue Avoidance Scheduling Tool analysis of his self-reported sleeping schedule (Tabs V-2.3 and X-5). Both MP1 and MP2 were in the latter half of their 12-hour duty day when the mishap occurred (Tabs R-2 to R-22 and X-6 to X-7). There is no evidence to suggest that crew rest or crew duty time were factors in the mishap (Tab X-6 to X-7).

Review of the maintenance members' 72-hour and 14-day histories indicated that their crew rest was adequate and IAW published guidance (Tabs X-6 to X-7 and BB-33).

10. OPERATIONS AND SUPERVISION

a. Operations

The 169th Operations Group (169 OG) executes a phase-based training plan via quarterly training cycles (Tab EE-3 to EE-13). The development of the training plan is deliberative and accounts for upgrades, home station training, exercises, deployments, tactical focus areas, and aircraft configuration/maintenance considerations (Tab EE-3 to EE-13). At the time of the mishap, the 169 OG was conducting the SEAD phase of training (Tab EE-3 and EE-8).

The 169 OG Commander stated the wing had executed "a challenging, but reasonable training plan and ops tempo with an emphasis on high quality joint, coalition and 5th gen[eration] training" (Tab EE-2). The wing deployed to multiple locations outside the continental United States including Lask, Poland from May to June 2015 and Rota Naval Air Station, Spain from February to March 2016 (Tab EE-3). The 2015 to 2016 training plan included the temporary duty evolutions of: Exercise Sentry Eagle in Klamath Falls, OR from July to August 2015; F-35 integration at Eglin AFB, FL in September 2015; Weapons Instructor Course Advanced Integration at Nellis AFB, NV in December 2015; and a Red Flag exercise at Nellis AFB, NV from January to February 2016 (Tab EE-3).

MP1's and MP2's recent operations tempo included five and eight sorties, respectively, within the previous 30 days (Tab G-6 and G-27).

There is no evidence to suggest that operations tempo was a factor in the mishap.

b. Supervision

Multiple levels of supervision were included in the coordination and flight briefs, which consisted of the MF and RF (Tab V-1.4). The MF included MP1, the 316 FS Commander; MP2, the IP of record; ME3, an IP; and ME4 (Tab K-3). The RF included RF1, the 157 FS Commander and an IP; and RF2, an IP (Tab K-3). Both MF and RF attended the step brief conducted by the OS who authorized the flight and included a review of aircraft status, weather, NOTAMs, ORM, and Go/No-Go items IAW AFI 11-418 (Tab V-10.2 to V-10.3).

There is no evidence to suggest supervision or lack of supervision was a factor in the mishap.

11. HUMAN FACTORS ANALYSIS

a. Inaccurate Expectation

“Inaccurate Expectation” is when an individual expects to perceive a certain reality and those expectations are strong enough to create a false perception of the expectation IAW DoD Human Factors Analysis and Classification System (HFACS) version 7.0 (nanocode PC110) (Tab BB-39).

Both MP1 and MP2 inaccurately judged their positions relative to each other following MP2's “Bingo” call (Tab V-1.12 and V-2.10). Both had the mental model of pursuing the other aircraft following MP1's final left turn (Tab V-1.12 and V-2.10). When presented with new data that conflicted with their expectations, each pilot was unable to process and translate the data into timely actions necessary to avoid the mishap (Tabs J-17, J-22, V-1.13, V2.12, GG-4 to GG-6).

Six seconds prior to the collision, MP1 was presented with HUD radar data showing MA1 and MA2 pointing directly at each other with only 1.5 nm of separation (Tab GG-4 to GG-6). MP1 had expected MA2 to be six miles away headed north (Tab V-1.12). His expectation that MP2 was headed away from him was so strong that he ignored that data and switched to an air-to-ground priority mode for SEAD operations (Tab GG-4 to GG-6). This action removed critical information, which would have warned MP1 of imminently collapsing distance (Tab GG-4 to GG-6).

During MP1's final left turn, MP2 visually tracked MA1's light moving from right to left on the horizon (Tab V-2.7). Per his testimony, MP2's last recalled distance from MA1 just prior to his left turn was “three-ish” nm, later verified as 3.8 nm by his A/A TACAN display (Tabs V-2.8 and GG-4 to GG-6). Based on an expectation that MA1 was continuing with a southern heading, MP2 was unaware that MA1 had in fact reversed direction and was headed toward him (Tab V-2.11). Over the next 14 seconds, MP2 attempted to acquire a visual boresight lock on MA1, did not attempt to clarify an earlier ambiguous radio call from MP1 to “track north”, or cross check distance with his A/A TACAN (Tabs N-2 and V-2.10). Although data reflected a descent from the sanctuary altitude, MP2 stated that he did not know if he was or was not descending during his

boresight lock attempts (Tabs J-22, V-2.9 to V-2.11, and GG-4 to GG-6). When he achieved the desired radar lock approximately six seconds before collision at a range of 2,500 feet separation, MP2 was presented with an immediate “Break X” symbol in his HUD (Tab GG-4 to GG-6). MP2 did not process the immediate peril due to his expectation that MA1 was moving away from him (Tab V-2.9).

Each pilot’s expectation that the other was moving away hampered timely evasive maneuvering. Lockheed Martin analysis of the flight controls showed no significant control inputs by either pilot until less than one second prior to the collision (Tab J-17 and J-22).

b. Fixation

“Fixation” is a factor when the individual is focusing all conscious attention on a limited number of environmental cues to the exclusion of others IAW DoD HFACS version 7.0 (nanocode PC102) (Tab BB-39).

MP2 was flying in a night visual wedge formation, which requires use of all available tools to ensure aircraft separation and deconfliction (Tabs V-1.7 to V-1.8, V-2.9, and BB-44). Night flying is challenging as there is degradation of both visibility and depth perception (Tab BB-49). MP2 had A/A TACAN and A/A FCR available to him as positional aides (Tab V-1.7). As MP2 tracked MA1, he descended from his sanctuary altitude while maintaining visual contact (Tabs J-22, V-2.9, and GG-4 to GG-6). MP2 maneuvered to place MA1’s lights in the center of his HUD, maintaining a pure pursuit course, never referencing his A/A TACAN (Tabs V-2.11 to V-2.12, and GG-4 to GG-6). During this 14-second block of time, MP2 made at least nine switch actuations in an attempt to acquire an FCR visual mode boresight lock on MA1 (Tab GG-4 to GG-6). He was unaware of MA1’s turn to the northeast due to fact that he exclusively relied on visual cues, and did not confirm MA1’s maneuver with available sensors (Tabs V-2.9 to V-2.11 and GG-4 to GG-6).

MP1 similarly over relied on visual cues and did not confirm closing distance with A/A TACAN following his unannounced left turn (Tabs J-17, V-1.12 and GG-4 to GG-6). MP1 immediately identified MA2 by the sequenced flashing lights and acquired a visual boresight lock on MA2 (Tabs V-1.12 and GG-4 to GG-6). MP1 relied on an inaccurate mental perception of MA2’s relative position and did not crosscheck his A/A TACAN, confirm his radar data or clarify MA2’s position on the radio (Tabs N-2, V-1.12, and GG-4 to GG-6). Unlike MP2 however, MP1 maintained his briefed sanctuary altitude (Tabs J-17, V-1.12, and Z-17).

c. Failure to Prioritize Task Adequately

“Failure to Prioritize Task Adequately” is a factor when the individual does not organize, based on accepted prioritization techniques, the tasks needed to manage the immediate situation IAW DoD HFACS version 7.0 (nanocode AE202) (Tab BB-37).

MP1 did not call “Knock it off” following MP2’s “Bingo” call (Tabs N-2 and V-1.15). Per AFI 11-214, an immediate “Knock it off” or “Terminate” radio transmission was required to have been called by the flight lead (MP1) to unequivocally cease tactical maneuvering and allow the mishap

flight to begin administrative maneuvering back to base (Tab BB-7). MP1's failure to call "Knock it off" created a misprioritization between tactical and administrative maneuvering (Tab V-2.7 to V-2.10). Without a "Knock It Off" call, MF continued tactical operations, further degrading radio communication between MP1 and MP2 (Tab N-2).

At the point MP2 called "Bingo", the overall mission objective of an Instructor Pilot Upgrade sortie for MP1 had already been met (Tab V-1.14). No other member of the MF had training requirements (Tab V-1.14). MP1 acknowledged that the training rules required termination (Tab V-1.15). Nevertheless, MP1 assessed that he "wanted them [ME-3, ME-4] to have that quick opportunity before I knock(ed) off the fight" (Tab V-1.14). The delay in a "Knock it off" call was secondary to MP1's desire to continue tactical maneuvering for the MF so that additional training could be achieved (Tab V-1.14). MP1 prioritized unnecessary training over a timely "Knock it off" call as required by AFI 11-214 (Tab V-1.14).

d. Failure to Effectively Communicate

"Failure to Effectively Communicate" is a factor when communication is not understood or misinterpreted as the result of behavior of either sender or receiver (Tab BB-40). Communication failed to include backing up, supportive feedback or acknowledgement to ensure that personnel correctly understood announcements or directives in accordance with DoD HFACS version 7.0 (nanocode PP108) (Tab BB-40).

Approximately 17 seconds prior to impact, after MP1 had nearly completed his left turn, transcripts show that MP1 made an unclear radio call ("Sorry, two, you can continue tracking north") (Tab N-2). Although MP1's communication was delayed, he believed MP2 would have turned north and would still be approximately six miles away from MA1 (Tab V-1.11 to V-1.12). MP2 acknowledged the call five seconds later ("Copy that") (Tab N-2). MP2 believed that "tracking north" was not a directive to change heading, but instead meant the mishap element would eventually flow north together in a visual wedge formation (Tab V-2.9). The other pilots interviewed also agreed that a "track north" instruction was ambiguous and would have merited further clarification (Tab V-3.5, V-5.8, and V-6.7 to V-6.8). Neither MP attempted to make a clarifying radio call (Tab N-2).

e. Complacency

"Complacency" is a factor when the individual has a false sense of security, is unaware of, or ignores hazards and is inattentive to risks IAW DoD HFACS version 7.0 (nanocode AE206) (Tab BB-38).

Cross-checking visual cues with other sensor data, altitude separation, and informative radio calls are required to ensure aircraft deconfliction as both depth perception and visibility are degraded during night operations (Tab BB-49). Prior to the mishap, MP2 stated he was flying a night visual wedge formation and that his intent was to flow south with MP1 (Tab V-2.9 to V-2.10). Both MP1 and MP2 testified that they were in a visual wedge formation (Tab V-1.7 and V-2.6). MP2 stated that, because he was in a visual formation, he did not need to adhere to his sanctuary altitude, believing instead that the sanctuary altitude was only for sensor formations (Tab V-2.11). MP2

observed MA1's external lights moving from right to left on the horizon but did not monitor with A/A TACAN or FCR to confirm MA1's maneuver (Tabs V-2.10 to V-2.12 and GG-4 to GG-6). Review of HUD video, showing MP2's attempted boresight lock indicated that the member was complacent in relying on visual cues as his primary means of deconfliction (Tab GG-4 to GG-6). MP2 did not crosscheck his visual perception against his available sensor data or attempt to clarify on the radio (Tabs N-2 and V-2.10). MP2's statement that he did not need to utilize his sanctuary altitude and decision not to crosscheck his visual observations against available instrumentation during night visual wedge formation led to a false sense of security, ignoring hazards, and was inattentive to risks (Tabs V-2.10 to V-2.12 and GG-4 to GG-6).

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Publically Available Directives and Publications Relevant to the Mishap

- (1) AFI 51-503, *Aerospace and Ground Accident Investigations*, 14 April 2015
 - (2) AFI 51-503 ACC Supplement, *Aerospace and Ground Accident Investigations*, 28 January 2016
 - (3) AFI 91-204, *Safety Investigations and Reports*, 10 April 2014
 - (4) AFI 48-123, *Medical Examinations and Standards*, 5 November 2013
 - (5) AFI 11-214, *Air Operations Rules and Procedures*, 14 August 2012, Incorporating Change 1, 23 March 2016
 - (6) AFI 11-418, *Operations Supervision*, 14 October 2015
 - (7) AFI 11-2F-16V3, *F-16--Operations Procedures*, 18 December 2013
 - (8) AFI 11-202V3, *General Flight Rules*, 7 November 2014
- NOTICE:** All directives and publications listed above are available digitally on the Air Force Departmental Publishing Office website at: <http://www.e-publishing.af.mil>.

b. Other Directives and Publications Relevant to the Mishap

- (1) DoD Human Factors Analysis and Classification System, version 7.0
- (2) AFTTP 3.3-F-16, *Combat Aircraft Fundamentals*, 14 September 2014
- (3) TO 00-20-2, *Maintenance Data Documentation*, 1 November 2012
- (4) TO 00-20-1, *Aerospace Equipment Maintenance Inspection Documentation, Policies, and Procedures*, 1 April 2016

c. Known or Suspected Deviations from Directives or Publications

None.

//Signed//

17 April 2018

RANDAL K. EFFERSON, Brig Gen, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

F-16C, T/N 93-0531 and F-16C, T/N 92-3899

LOUISVILLE, GA

7 JUNE 2016

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.

2. OPINION SUMMARY

a. SUMMARY OF MISSION

On 7 June 2016, the mishap flight (MF) of four F-16Cs, call sign Mace 31 (Mishap Pilot 1 – MP1), Mace 32 (Mishap Pilot 2 – MP2), Mace 33 (Mishap Element 3 – ME3), and Mace 34 (Mishap Element 4 – ME4) performed a day, transition to night, Suppression of Enemy Air Defense (SEAD) training mission with two other F-16s, call sign, Viper 41 (Red Flight 1 – RF1) and Viper 42 (Red Flight 2 – RF2). MP1 was an active duty F-16C instructor pilot with more than 1,900 hours in the F-16. The overall mission objective for the MF was for MP1 to accomplish an additionally mandated 169th Fighter Wing (169 FW) instructor pilot qualification program, following his recent assignment to the 169 FW as the 316th Fighter Squadron commander. MP1 was the MF flight leader during the upgrade sortie. MP2 was the instructor pilot for the upgrade and had more than 1,600 hours in the F-16. The MF take off time was 2015 local time (L). The mission was flown in the Bulldog Military Operating Area (MOA) approximately 100 miles southwest of McEntire Joint National Guard Base (JNGB). At 2114L, just before the end of tactical maneuvering, Mishap Aircraft 2 (MA2), tail number 93-0531, collided with Mishap Aircraft 1 (MA1), tail number 92-3899.

The briefed SEAD plan was for the MF to conduct two training scenarios with the first being a flow-through tactic where Red Flight (RF) would act as air-to-air adversaries and then change roles to become friendly strikers to be escorted through the target area by the MF. The second scenario was for the MF to conduct SEAD operations from a geographically fixed Combat Air Patrol location oriented toward a target area. In this scenario, RF would again act as adversary air and then re-role as friendly strikers that would ingress and egress the target area.

At the very end of the second scenario, MA1 and MA2 were both on northwesterly headings, away from the target area when MP2 radioed that he had reached Bingo fuel. “Bingo” means an aircraft has reached the predetermined minimum fuel state when it is time to terminate tactical maneuvering, rejoin the flight into an administrative formation, and return home. At the time of MP2’s “Bingo” call, MA2 was behind MA1 in a visual wedge formation with an altitude stack.

MP1, however, did not terminate tactical maneuvering via a “Terminate” or “Knock it off” radio transmission, as required by Air Force Instruction (AFI) 11-214. Instead, he began an unannounced left turn, reversing his direction, towards MA2, while remaining at his pre-briefed sanctuary altitude of 15,000 feet Mean Sea Level (MSL). MP1 made two unclear radio calls after he had begun his turn in an attempt to direct MP2 to make a right hand turn north. MP1 intended to rejoin with MA2 in a parallel formation that would be several miles apart and headed north. Adding to the confusion, when MP1 began his turn, he incorrectly believed that MA2 was 10 nautical miles (nm) behind, based on an earlier tactical separation. MP1 did not check his air-to-air tactical air navigation system (A/A TACAN) distance measuring equipment before turning or query MP2 for his position. Neither of MP1’s radio calls effectively communicated (human factor) his intent because his instructions were incomplete and out of context. The radios were also busy with higher priority tactical scenario communications by the other four F-16s still fighting the SEAD scenario.

Following MP1’s left turn, he was visual with MA2’s distinctive double flash anti-collision light. MP1 then intentionally acquired an air-to-air Fire Control Radar (FCR) visual mode boresight lock on MA2. An FCR visual mode boresight lock requires the locking aircraft to point directly at the target until the lock is achieved in what is known as a pure pursuit course. The FCR lock occurred six seconds before impact, displaying 1.5 nm separation and indicating a head-on conflict existed. MP1, however, failed to recognize the impending hazard based on his inaccurate mental expectation (human factor) that MA2 was still several miles away and heading north. MP1’s mental perception was so strong that he changed his FCR to an air-to-ground priority mode for SEAD operations, which removed critical information from his HUD. MP1 never recognized the impending collision potential until it was too late.

MA2 was at 15,860 MSL and 3.8 nm behind MA1 before MA1’s turn, which is slightly beyond the 1-3 nm limits of the assigned visual wedge formation position. MP2 observed MA1’s external lights move from right to left on the horizon indicating a turn but did not monitor his A/A TACAN or FCR to confirm MA1’s maneuver. Consequently, MP2 did not realize MA1 had made a complete direction reversal from heading 280 to 053 degrees.

MP2 interpreted MP1’s radio transmissions to mean he was expected to stay in formation and that the two of them would eventually turn north together. Shortly after MP2 observed MA1’s lights move from right to left, MP2 began an attempt to acquire an FCR boresight lock on MA1. The attempt took 14 seconds to work, during which time MP2 descended from a peak altitude of 15,860 MSL to the collision altitude of 15,280 MSL and range closed to well under one mile. During MP2’s 14-second radar lock attempt, he did not cross-reference his A/A TACAN range or ask MP1 for a reference heading. MP2 stated that he became fixated (human factor) on MA1’s lights. Approximately two seconds prior to impact, MP2 achieved a radar lock on MA1 with 2,500 feet separation but failed to process the information and recognize the conflict, due to his inaccurate expectation (human factor) that MA1 was headed away from him. MP2 maintained a pure pursuit course until impact. At the last fraction of a second, both aircraft initiated a left bank away from the other and the high right wings collided. MP1 and MP2 were unable to regain control of their aircraft. MP2 ejected 21 seconds after collision, and MP1 ejected 53 seconds after collision.

Based on the evidence, I believe MP2 was attempting to remain in formation behind MA1, thinking that a “Knock it off” call would occur shortly based on his earlier “Bingo” call. Although MP2

had no memory of the 14-second boresight lock attempt, I believe MP2's intention was to take a radar lock and remain comfortably behind MA1 in a trail formation.

b. SUMMARY OF CAUSATION & SUBSTANTIALLY CONTRIBUTING FACTORS

I find by a preponderance of the evidence that the cause of the mishap was MP2's failure to fulfill his primary responsibility to ensure flight path deconfliction and separation of aircraft. Additionally, I find by a preponderance of the evidence that there were two substantially contributing factors to the mishap: (1) MP1 did not terminate tactical maneuvering following MP2's "Bingo" fuel call and (2) MP1 and MP2 overly relied on visual cues from external aircraft lighting to judge critical flight parameters.

I developed my opinion by analyzing recorded flight data, interviewing mishap flight pilots, adversary air pilots, supervisory pilots, directives, animated simulations, information provided by technical experts, and other witness testimony.

2. CAUSE

I find by a preponderance of the evidence that the cause of the mishap was MP2's failure to fulfill his primary responsibility to ensure flight path deconfliction and separation of aircraft. This occurred when MP2 left his assigned sanctuary altitude without the situational awareness required to ensure deconfliction with MA1.

Shortly before the mishap, MP2 was assigned to fly in a night visual wedge formation, defined as 1-3 nm behind and within a 30 to 70 degree cone around the flight lead. MP2 was also assigned a sanctuary altitude of 16,000 MSL, which was 1,000 feet above MA1's sanctuary altitude. Air Force Tactics Techniques and Procedures (AFTTP) 3-3.F-16 states that altitude separation should be used at night for both visual and sensor formations. Sanctuary altitudes should be utilized during night formation anytime the wingman is not certain of the spatial orientation, position, maneuver of the lead aircraft, or is otherwise unable to ensure deconfliction. Wingmen may deviate from their sanctuary altitude for a variety of reasons, such as weapons employment, threat reactions, when seeking better environmental conditions for maintaining visual contact with the flight lead, or any required maneuver to stay within formation parameters, as long as it does not create a conflict with any member of the flight.

AFTTP 3-3.F-16 further provides that, during formation flying, wingmen will use all available tools to ensure aircraft deconfliction. Increasing the complexity of MP2's primary task was that he had very few available sensors for station keeping. The normally available sensors for night formation flying are night vision goggles (NVGs), Link-16 military data exchange network, FCR, A/A TACAN, radio, and visual cues. On this night, NVGs were not worn because the sky glow was too bright during day/night transition timeframe. MA1's and MA2's Link-16 systems were not working, but the briefed contingency was increased reliance on remaining sensors. MP1 and MP2 only had the FCR and A/A TACAN to monitor formation positions. Operating with degraded systems requires that pilots pay greater attention to the remaining sensors to ensure aircraft deconfliction.

Based upon testimony, HUD video, and in-flight audio recordings, it is clear MP2 relied exclusively on visual contact with MA1 for an extended period of time. MP2 failed to monitor critical flight data before and after MA1 executed a left turn from heading 280 to 053. The fact that MP2 had so few available positional confirmatory tools placed even greater emphasis on striving to maintain altitude separation at all times.

MP2's over reliance on visual cues was further demonstrated by MP2 pointing the nose of his aircraft directly at MA1 until collision. MP2 stated his last recollection was he was approximately "three-ish miles" behind MA1 when he visually tracked MA1's lights move from right to left on the horizon, indicating a slight southern or left turn. MP2 stated he became fixated (human factor) on MA1's external lights, meaning he was exclusively focused on maintaining visual contact. The next thing MP2 said he remembered was seeing MA1's green engine intake light as the aircraft collided. MA2's A/A TACAN information displayed a distance of 3.8 nm from MA1 before MP1 began his left turn and decreased as MA1 completed his maneuver. MP2 did not recognize this fact because he did not crosscheck the A/A TACAN or use his FCR in a sweep mode to show raw FCR data. Instead of monitoring his available sensors, MP2 began an attempt to acquire a visual mode FCR boresight lock on MA1. Boresight lock mechanics require that MA2 point directly at MA1 until the FCR lock was achieved and A/A TACAN data is removed from the HUD. During the 14 seconds MP2 attempted the boresight lock he exhibited fixation (human factor) while descending from a peak altitude of 15,860 MSL to the collision altitude of 15,280 MSL. Although MP2 made nine switch actuations during the attempted boresight lock, he stated he had no memory of trying to acquire the lock.

Approximately two seconds before the collision, MP2 successfully achieved a radar lock, which indicated a range of 2,500 feet between MA1 and MA2. MP2's HUD immediately displayed impending collision symbology, known as a Break-X, with a designation circle around MA1 indicating that a head-on condition existed. Unfortunately, MP2 missed this last opportunity to deconflict.

MP2 stated he did not need to be at his assigned sanctuary altitude because he was in a visual formation. Under the given environmental conditions, however, being visual only meant MP2 knew the exact azimuth of MA1. MP2's naked eye did not provide performance data such as range, aspect, heading, and altitude that were all required to comply with formation contracts. During formation flying, wingmen must use all available tools to ensure separation of aircraft. The mishap occurred because MP2 failed to fulfill his primary responsibility to maintain deconfliction and separation of aircraft, leaving his assigned sanctuary altitude without the necessary situational awareness to do so.

3. SUBSTANTIALLY CONTRIBUTING FACTORS

a. MP1 did not terminate tactical maneuvering following MP2's "Bingo" fuel call.

At 21:13:23L MP2 made a "Bingo" radio call, which is a pre-briefed fuel state requiring termination of tactical maneuvering. Bingo fuel is set at a level that allows aircraft to return to the

base of intended landing with normal recovery fuel. MP1 acknowledged MP2's "Bingo" call four seconds later, but intentionally chose not to terminate the tactical training scenario in an attempt to allow ME3 and ME4 to get more training. The collision occurred 40 seconds after MP2's "Bingo" call. I find by a preponderance of the evidence that MP1's failure to call "Terminate" or "Knock it off" after acknowledging MP2's "Bingo" call substantially contributed to the mishap. MP1's decision not to terminate tactical maneuvering reflected a misprioritization (human factor) between tactical scenario and administrative maneuvering, and demonstrated ineffective communication (human factor) between MP1 and MP2.

AFI 11-214, *Air Operations Rules and Procedures*, requires a termination of all tactical maneuvering when a member of the flight reaches Bingo fuel via either a "Terminate" or "Knock it off" radio transmission. The purpose of this call is to have a clear and concise end to tactical maneuvering so all members of a given flight make the mental shift from defeating an enemy to the administrative functions of rejoining the flight into an approved formation to transit between the operating area and their home base.

Instead of terminating when MP2 called "Bingo," MP1 started a left turn from 280 to 053 with the intention to rejoin with MA2 while ME3 and ME4 continued with the tactical maneuvering. When MP1 began his turn, he did not make the AFTTP 3-3.F16 required radio call announcing his maneuver. He failed to make that call because the radio was busy with weapons employment and tactical maneuvering communications by ME3, ME4, and RF. Had MP1 called "Knock it off," all further radio calls would have been prioritized to the administrative functions of rejoining the formation to return home. The result of not terminating immediately was that MP1's administrative rejoin actions and attempted communications were embedded with tactical communications and out of context.

The actions of MP1 and MP2 demonstrate the confusion resulting from overlapping tactical and administrative communications. MP1 did not make his first attempt at communicating the rejoin plan until he was already half way through his left turn, when he mistakenly told ME4 "you can continue north", but intending the communication for MP2 as an administrative directive. ME4 answered that he was attacking a surface to air missile site in the north, which was a tactical communication. At the same time, MP2 had already begun to follow MA1's external lights. MP1's second administrative communication to MP2 came just before MA1 completed the left turn, with range closing rapidly, when he provided the unclear radio call ("Sorry, two, you can continue tracking north"). MP2 acknowledged ("Copy that") but did not interpret the instruction as a directive for him to turn north. MP2 believed MP1 expected him to remain in formation and that both of them were preparing to turn north together. The last two radio calls before the collision were both tactical calls by other flight members regarding a formation turn by ME3 and ME4 and an enemy aircraft location call from RF, reflecting a continuation of tactical maneuvering.

MP1's decision to delay calling "Knock it off" after the "Bingo" call was based on his desire to continue tactical maneuvering so that other members of the MF could get additional training. AFI 11-214 requires termination of a training flight when the predetermined desired learning objectives (DLOs) are achieved. The overall mission objective was to accomplish an instructor pilot upgrade for MP1. No other member of the MF or RF had critical training requirements. Therefore, at the time of MP2's "Bingo" call, the DLOs for the flight were complete. MP1 misprioritized (human

factor) unnecessary training over timely compliance with AFI 11-214 directives. While this decision did not cause the mishap, it substantially contributed to the confusion that led to the collision.

b. MP1 and MP2 overly relied on visual cues from external aircraft lighting to judge critical flight parameters.

The mishap mission occurred during and after the civil twilight time period, which is one of the most challenging times to conduct simulated combat operations. This is because NVGs are not yet effective but the naked eye can no longer distinguish critical flight data. AFTTP 3-3.F-16 defines visual formations as only those less than three nm. Formations outside three nm are defined as sensor formations because it is too difficult for the wingman to tell whether the flight lead is turning left/right or pointing directly towards/away. During daytime, “visual” means a pilot can discern critical flight parameters and maneuver in relation to another aircraft with ease, as in a dogfight or basic formation. During civil twilight, the naked eye slowly loses the ability to judge range, aspect, heading, and closure with another aircraft so a pilot must place greater emphasis on sensor data to maintain position. AFTTP 3-3.F-16 requires that unplanned turns or changes in airspeed/altitude by the leader be preceded by an informative radio call at night. This alerts wingmen to place greater emphasis on monitoring formation position while maneuvering. The mishap occurred 10 minutes after the end of civil twilight and all pilots acknowledged that they were operating under night rules, which means radio calls for unplanned turns were required.

AFTTP 3-3.F-16 further provides that, during all formation flying, wingmen will use all available tools to ensure aircraft deconfliction. Since NVGs were not worn and Link-16 was not working, the only real time sensors available to both MP1 and MP2 were A/A TACAN and FCR.

MP1 perceived MA2 to be approximately 10 nm in trail before making his left turn from heading 280 to 053 degrees. MP1 did not remember cross checking his A/A TACAN range before he turned, which was his only available situational awareness tool. He could not use his FCR because MA2 was behind him. As MP1 completed his left turn, he took a visual boresight FCR lock on MA2 but felt no need to crosscheck the range because of his earlier misperception that MA2 was 10 nm behind. MP1 knew he was attempting an FCR lock on MA2 based on the specific anti-collision light flash sequence being emitted. MA1’s FCR data clearly confirmed that MA1 and MA2 were 1.5 nm apart and pointed directly at each other, but MP1 was unable to process this information due to his overriding mental perception (human factor) that MA2 should still be several miles away and headed north.

Although MP1 visually saw MA2’s external lights, he could not tell whether MA2 was three miles away or 10 miles away. Combined with failing to crosscheck his A/A TACAN and ignoring his FCR data, it is clear that MP1 relied on visual indications from external lighting to make critical decisions. AFTTP 3-3.F-16, however, has multiple references to the hazards of formation flying, night intercepts, and rejoins that highlight the importance of focusing on sensors and procedures (FCR, A/A TACAN, Link 16, altitude separation, radio calls) in addition to visual cues (NVGs or naked eye). To his credit, MP1 remained at his briefed sanctuary altitude.

When MP2 observed MA1's lights track from right to left, MP2 became fixated (human factor) on MA1's external lights at the cost of ignoring critical flight data. However, before MP1 began the final left turn, MP2 did recognize that he was at 3.8 nm spacing. IAW AFTTP 3-3.F-16 contracts, at that range MP2 was obligated to make a radio call ("MP2, stripped, four miles") informing MP1 that he was slightly outside the proper formation position. Although (a) MP2's failure to make a stripped call with his actual range and (b) MP1's failure to announce his left turn complicated situational awareness for both MPs, these were not causal. Missed, incomplete, stepped on, or incorrect radio calls often occur but do not override a wingman's primary responsibility to maintain flight deconfliction using all available data. When MP2 saw MA1 track from right to left on the horizon, he should have used his FCR and A/A TACAN to confirm the maneuver.

On this night, MP2 had the additional responsibility as the instructor pilot of record. That means MP2 must not only comply with formation contracts but also remain on constant alert for MP1, as the trainee, to make mistakes, miss radio calls, turn unexpectedly, or make incorrect decisions. AFTTP 3-3.F-16 states that there are no visual formations outside three nm. Formations at any distance over three nm are sensor formations and a greater reliance on available sensors is required to maintain situational awareness. AFTTP 3-3.F-16 states when in sensor formation, range is expected to naturally collapse during turns and wingmen will be required to delay turns to maintain spacing. For this reason, AFI 11-2F-16V3 emphasizes wingmen will strive to maintain an altitude stack at all times during sensor formation. In addition, the farther away an aircraft is when observing another aircraft turn from a distance, the shorter the arc distance their lights will draw on the horizon. MP2 knew his range from MA1 and observed MA1 draw a right to left arc on the horizon. At 3.8 nm behind he observed MA1 make a normal 180 degree tactical turn. As an experienced F-16 instructor pilot, MP2 should have been aware of the potential conflict and vigilantly monitored available sensors while adhering to his sanctuary altitude.

MP2's statement that he did not need to utilize his sanctuary altitude or cross-check his visual observations against available instrumentation during night visual wedge formation indicates an attitude that ignored hazards and was inattentive to risks associated with night flying. I believe MP2 exhibited signs of complacency (human factor), based on his experience/comfort flying at night and over reliance on visual cues.

4. CONCLUSION

I find by a preponderance of the evidence the mishap was caused by MP2's failure to fulfill his primary responsibility to ensure flight path deconfliction and separation of aircraft. Additionally, I find there are two substantially contributing factors to the mishap: (1) MP1 did not terminate tactical maneuvering following MP2's "Bingo" fuel call and (2) MP1 and MP2 overly relied on visual cues from external aircraft lighting to judge critical flight parameters.

//Signed//

17 April 2018

RANDAL K. EFFERSON, Brig Gen, USAF
President, Accident Investigation Board

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Releasable Photographs, Videos, Diagrams, and Animations	S
Personnel Flight Records Not Included In Tab G.....	T
Maintenance Report, Records, And Data Not Included In Tab D	U

Witness Testimony And Statements	V
Weather And Environmental Records, and Data Not Included In Tab F	W
Statements of Injury or Death	X
Legal Board Appointment Documents	Y
Photographs, Videos, Diagrams, and Animations Not Included In Tab S	Z
Flight Documents	AA
Applicable Regulations, Directives, and Other Government Documents	BB
Fact Sheets	CC
Analysis of Escape System	DD
Training Documents.....	EE
Mishap Documents	FF
Miscellaneous Documents	GG