

UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION
BOARD REPORT



F-15E STRIKE EAGLE, T/N 91-000304

**492D FIGHTER SQUADRON
48TH FIGHTER WING
ROYAL AIR FORCE LAKENHEATH, UNITED KINGDOM**



ACCIDENT LOCATION: NEAR BENGHAZI, LIBYA

DATE OF ACCIDENT: 21 MARCH 2011

BOARD PRESIDENT: COLONEL SCOTT D. SHAPIRO

F-15E, T/N 91-000304, 21 March 2011

UNITED STATES AIR FORCE AIRCRAFT ACCIDENT INVESTIGATION BOARD

EXECUTIVE SUMMARY

F-15E STRIKE EAGLE, T/N 91-000304 NEAR BENGHAZI, LIBYA 21 MARCH 2011

On 21 March 2011, at approximately 2129 hours Zulu (Z), an F-15E Strike Eagle, tail number 91-000304, departed controlled flight and entered into an unrecoverable spin during a night combat mission in support of Operation ODYSSEY DAWN. The mishap aircraft (MA), operated by the 492d Expeditionary Fighter Squadron based out of Aviano Air Base (AB), Italy (IT), was destroyed on ground impact in an unpopulated area near Benghazi, Libya. The mishap aircrew (MC), consisting of the mishap pilot (MP) and the mishap weapons system officer (MW), ejected safely with minor injuries and was recovered by friendly forces. Financial loss of the MA and associated equipment totaled \$48,190,996.50. There were no known civilian injuries or damage to other property.

At 1713Z, the MC performed a standard takeoff from Aviano AB, IT, for night contingency operations over Libya. The MA was number two (wingman) of two F-15Es in formation. At 2104Z, after refueling uneventfully a second time, the MC proceeded on its mission tasking. Within five minutes, the MC relayed a fuel imbalance of 2,500 pounds trapped in the right external tank. At 2111Z and again at 2112Z, the MC reported that the trapped fuel was feeding slowly. At 2127Z, with the MA advancing approximately two miles ahead in the formation, the two aircraft released munitions and attempted target egress by executing a turn away from each other. At 2128Z, the MC radioed they were in a spin, a "Mayday" call followed, and at 2129Z, the MC ejected from the MA.

The Accident Investigation Board President found by clear and convincing evidence that the cause of the mishap was the MA's sudden departure from controlled flight during a combat egress maneuver when the MP momentarily exceeded aircraft controllability performance parameters. There was sufficient evidence to determine that one or a combination of the following factors substantially contributed to the mishap: (1) ambiguous F-15E technical order guidance concerning maneuvering limitations with aircraft lateral asymmetry while configured with external stores; (2) unknown or misunderstood combat-loaded F-15E aircraft performance while operating at or above 30,000 feet mean sea level; and (3) unpublished, therefore, unfamiliar dynamic lateral directional stability as a function of external stores asymmetry caused by weapons release.

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

TABLE OF CONTENTS

F-15E STRIKE EAGLE, T/N 91-000304 NEAR BENGHAZI, LIBYA 21 MARCH 2011

EXECUTIVE SUMMARY	i
TABLE OF CONTENTS	ii
COMMONLY USED ACRONYMS AND ABBREVIATIONS	v
SUMMARY OF FACTS	1
1. AUTHORITY, PURPOSE, AND CIRCUMSTANCES	1
a. Authority	1
b. Purpose	1
c. Circumstances	1
2. ACCIDENT SUMMARY	1
3. BACKGROUND	2
a. Air Force Command Structure and Organizational Responsibilities	2
(1) United States Air Forces in Europe (Ramstein Air Base, Germany)	2
(2) 48th Fighter Wing (RAF Lakenheath, UK)	3
(3) 492d Fighter Squadron (RAF Lakenheath, UK)	3
(4) 48th Aircraft Maintenance Squadron / 494th Aircraft Maintenance Unit (RAF Lakenheath, UK)	3
b. F-15E Strike Eagle	4
c. Operation ODYSSEY DAWN	5
4. SEQUENCE OF EVENTS	6
a. Mission	6
b. Planning	6
c. Preflight	8
d. Summary of Accident	8
e. Impact	10
f. Egress and Aircrew Flight Equipment	11
g. Search and Rescue	12
5. MAINTENANCE	12
a. Forms Documentation	12
(1) General Definitions	12
(2) General Documentation Reviewed	12
(3) Documentation Specific to the Automatic Flight Control System	13
b. Inspections	13
(1) Aircraft Inspections	13
(2) Engine Inspections	14
c. Maintenance Procedures	14
(1) AFCS Maintenance Procedures	14
(2) Discrepancies with AFCS Maintenance Procedures	14

d.	Maintenance Personnel and Supervision.....	15
e.	Fuel, Hydraulic Fluids, and Engine Oil Inspection Analysis	16
f.	Unscheduled Maintenance.....	16
6.	AIRCRAFT AND AIRFRAME SYSTEMS.....	16
a.	Affected Aircraft and Airframe Systems.....	16
b.	Condition of Systems.....	16
c.	Testing and Analysis	16
(1)	Aircraft Components and Systems of Interest.....	17
(2)	Simulator Evaluation	17
7.	WEATHER.....	21
a.	Forecast Weather	21
b.	Observed Weather	22
c.	Space Environment.....	22
8.	CREW QUALIFICATIONS	22
a.	Training and Qualification.....	22
b.	Experience in the F-15E Strike Eagle.....	22
(1)	Mishap Pilot.....	22
(2)	Mishap Weapons System Officer	23
9.	MEDICAL.....	23
a.	Qualifications.....	23
b.	Health Prior to Mishap	23
c.	Post-Mishap Injuries.....	23
d.	Toxicology	24
e.	Lifestyle	24
f.	Adequacy of Rest and Duty Periods.....	24
(1)	Aircrew—Rest and Flight Duty Periods.....	24
(2)	Maintenance Personnel—Rest Periods and Duty Shifts.....	25
10.	OPERATIONS AND SUPERVISION.....	25
a.	Operations.....	25
b.	Supervision	25
11.	HUMAN FACTORS ANALYSIS	26
a.	General Definitions.....	26
b.	Applicable Human Factors	26
(1)	Organizational Processes: Procedural Guidance/Publications	26
(2)	Organizational Climate: Perceptions of Equipment	27
(3)	Skill-Based and Judgment-Based Errors: Overcontrol/Undercontrol and Necessary Action—Rushed.....	27
(4)	Condition of Individuals: Channelized Attention and Cognitive Task Oversaturation	28
(5)	Supervisory Violations: Currency	28
12.	GOVERNING DIRECTIVES AND PUBLICATIONS.....	28
a.	Operations Directives and Publications.....	28
b.	Maintenance Directives and Publications.....	29
c.	Known Deviations from Directives or Publications.....	29

13. ADDITIONAL AREAS OF CONCERN.....	29
STATEMENT OF OPINION.....	31
1. OPINION SUMMARY.....	31
2. DISCUSSION OF OPINION.....	31
a. Misunderstood Aircraft Lateral Asymmetry Limitations.....	32
b. Unknown or Misunderstood Combat Loaded F-15E Performance.....	32
c. Lateral Asymmetry Awareness.....	33
3. CONCLUSION.....	33
INDEX OF TABS.....	34

COMMONLY USED ACRONYMS AND ABBREVIATIONS

48 AMXS	48th Aircraft Maintenance Squadron	CSEL	Combat Survivor Evader Locator
48 FW	48th Fighter Wing	DoD	Department of Defense
492 FS	492d Fighter Squadron	DTM	Data Transfer Module
492 EFS	492d Expeditionary Fighter Squadron	EFS	Expeditionary Fighter Squadron
494 AMU	494th Aircraft Maintenance Unit	FCC	Flight Control Computer
A/A	Air-to-Air	FDP	Flight Duty Period
A/G	Air-to-Ground	FL	Flight Level
AAA	Anti-Aircraft Artillery	FOD	Foreign Object Damage
AB	Air Base	FS	Fighter Squadron
ACES II	Advanced Concept Ejection Seat II	ft	feet
AF	Air Force	ft-lbs	feet-pounds
AFB	Air Force Base	FW	Fighter Wing
AFCS	Automated Flight Control System	GBU	Guided Bomb Unit
AFE	Aircrew Flight Equipment	HFACS	Human Factor Analysis and Classification System
AFI	Air Force Instruction	IAW	In Accordance With
AFPAM	Air Force Pamphlet	IMDS	Integrated Maintenance Data System
AFRICOM	U.S. Africa Command	IT	Italy
AFTO	Air Force Technical Order	JDAM	Joint Direct Attack Munitions
AFTTP	Air Force Tactics Techniques and Procedures	JFACC	Joint Forces Air Component Commander
AGL	Above Ground Level	JFMCC	Joint Forces Maritime Component Commander
AIB	Accident Investigation Board	JTF-OD	Joint Task Force ODYSSEY DAWN
AIM	Air Interdiction Missile	LANTIRN	Low Altitude Night Target And Infrared Navigation
AMRAAM	Advanced Medium Range Air-to-Air Missile	lb	pound
AMU	Aircraft Maintenance Unit	LC	Left Conformal
AMXS	Aircraft Maintenance Squadron	LRU	Line Replaceable Units
AOA	Angle of Attack	M	Mach
AOR	Area of Responsibility	M-BIT	Maintenance Built-In Test
ATO	Air Tasking Order	MA	Mishap Aircraft
BDA	Bomb Damage Assessment	MC	Mishap Crew
BIT	Built-In Test	MEF	Mission Execution Forecast
Bolar 33	Mishap Flight Lead Aircraft (call sign)	MF	Mishap Formation
Bolar 34	Mishap Aircraft (call sign)	MFLA	Mishap Formation Lead Aircraft
CAS	Control Augmentation System	MFLP	Mishap Formation Lead Pilot
CFT	Conformal Fuel Tank	MFLW	Mishap Formation Lead
CPU	Cockpit Units		

	Weapons System Officer	SRU	Shop Replaceable Units
mm	millimeters	Sta	Station
MP	Mishap Pilot	TCTO	Time Compliance Technical
MSL	Mean Sea Level		Orders
MTC	Mission Training Center	T/N	Tail Number
MW	Mishap Weapons System Officer	TO	Technical Order
NATO	North Atlantic Treaty Organization	U.S.	United States
NOTAMS	Notices to Airmen	UK	United Kingdom
OFFP	Operational Flight Program	UN	United Nations
ORM	Operational Risk Management	USAF	United States Air Force
P-BIT	Pilot Built-In Test	USAFE	United States Air Forces in Europe
PR	Problem Report	USEUCOM	United States European Command
RAF	Royal Air Force	USS	United States Ship
RC	Right Conformal	WSO	Weapons System Officer
S6E	Suite 6E	Z	Zulu
SDB	Small Diameter Bomb		
SLAM-ER	Standoff Land Attack Missile Extended Range		

The above list of acronyms and abbreviations was compiled from the Summary of Facts, Statement of Opinion, Index of Tabs, as well as Witness Testimony and Statements (Tab V), and Memoranda for Record (Tab AA).

UNITED STATES AIR FORCE AIRCRAFT ACCIDENT INVESTIGATION BOARD

SUMMARY OF FACTS

F-15E STRIKE EAGLE, T/N 91-000304
NEAR BENGHAZI, LIBYA
21 MARCH 2011

1. AUTHORITY, PURPOSE, AND CIRCUMSTANCES

a. Authority

On 23 June 2011, Lieutenant General Stephen P. Mueller, Vice Commander, United States Air Forces in Europe (USAFE), United States Air Force (USAF), appointed Colonel Scott D. Shapiro as the President of the Accident Investigation Board (AIB) convened to investigate the Class A aircraft mishap involving F-15E Strike Eagle, tail number (T/N) 91-000304, which occurred on 21 March 2011 near Benghazi, Libya (Tabs Y-3 and Y-4). Additional members appointed to the AIB were Lieutenant Colonel (Pilot Member), Senior Master Sergeant (Maintenance Member), Captain (Medical Member), Captain (Legal Advisor), and Staff Sergeant (Recorder) (Tabs Y-3 to Y-9). The investigation was conducted at Royal Air Force (RAF) Lakenheath, United Kingdom (UK), from 28 June 2011 through 30 August 2011 in accordance with Air Force Instruction (AFI) 51-503, *Aerospace Accident Investigations*, dated 26 May 2010 (Tabs Y-3 to Y-4).

b. Purpose

The purpose of this investigation is to inquire into the facts and circumstances surrounding the accident, to prepare a publicly releasable report, to gather and preserve evidence for use in litigation, claims, disciplinary actions, administrative proceedings, and for other purposes.

c. Circumstances

On 21 March 2011, the mishap aircraft (MA), a USAFE aircraft assigned to the 48th Fighter Wing (48 FW) at RAF Lakenheath, UK, was performing a night combat mission over Libya as part of Joint Task Force ODYSSEY DAWN. At the time of the mishap, the MA was operated by the 492d Expeditionary Fighter Squadron (492 EFS) and maintained by the 31st Expeditionary Aircraft Maintenance Squadron (31 EAMXS) both based out of Aviano Air Base (AB), Italy (IT) (Tabs K-3 to K-6, V-1.3, V-1.6, V-1.7, V-5-3, and V-5.4).

2. ACCIDENT SUMMARY

On 21 March 2011, at 1713 hours Zulu (Z), after normal maintenance, minor additional ground maintenance, and normal pre-flight checks, the F-15E Strike Eagle, T/N 91-000304, performed a standard takeoff from Aviano AB, IT, for night contingency operations over Libya in support of Operation ODYSSEY DAWN (Tabs K-3 to K-6, V-1.6, and V-1.7). The MA was number two

(wingman) of two F-15Es in formation. At 2104Z, the mishap formation (MF) completed aerial refueling and proceeded on its mission tasking. Within five minutes after refueling, the mishap aircrew (MC), consisting of the mishap pilot (MP) and the mishap weapons system officer (MW), relayed a fuel imbalance of 2,500 pounds trapped in the right external tank. At 2111Z and again at 2112Z, the MC reported that the trapped fuel was feeding to the engine slowly. At 2127Z, with the MA advancing approximately two miles ahead in the formation, the two aircraft released munitions and attempted target egress executing a turn away from each other. At 2128Z, the MC radioed they were in a spin, a "Mayday" call followed, and at 2129Z, the MC ejected from the MA (Tabs N-3 to N-5, R-4 to R-5, R-8 to R-9, R-37, R-48 to R-49, V-3.5, and V-4.10). Shortly after, the MA impacted the ground in an unpopulated area near Benghazi, Libya and was destroyed. The MC sustained minor injuries and was recovered by friendly forces. Financial loss of the MA and associated equipment totaled \$48,190,996.50. There were no known civilian injuries or damage to other property (Tabs P-5 and X-3).

3. BACKGROUND

The MA, a USAFE asset, was assigned to the 492d Fighter Squadron (492 FS) of 48 FW located at RAF Lakenheath, UK. At the time of the mishap, the MA was operated by 492 EFS, which was deployed in support of Operation ODYSSEY DAWN to Aviano AB, IT. 494 EFS consisted of their own home-station members from both the 492 FS, as well as members from their sister squadron, the 494 FS, both out of RAF Lakenheath, UK. Maintenance on the aircraft at the time was performed by the 494th Aircraft Maintenance Unit (494 AMU), which is part of the 48th Aircraft Maintenance Squadron (48 AMXS). During Operation ODYSSEY DAWN, however, 48 AMXS was under the deployed operational control of the 31 EAMXS out of Aviano AB, IT (Tabs K-3 to K-6, CC-5, CC-10 to CC-13, CC-19, and CC-21).

a. Air Force Command Structure and Organizational Responsibilities

(1) United States Air Forces in Europe (Ramstein Air Base, Germany)

United States Air Forces in Europe (USAFE), headquartered at Ramstein AB, near Kaiserslautern, Germany, is one of ten major commands of the USAF. USAFE reports to Headquarters, United States Air Force. The Command's mission involves directing air operations in a theater spanning three continents, covering more than eight million square miles. Its role includes warfighting, humanitarian and peacekeeping operations, as well as other non-traditional contingencies. Mainly an Air Expeditionary Force, USAFE trains and maintains combat-ready personnel and resources, thus ensuring a mobile and deployable force that can operate in multiple locations simultaneously. USAFE consists of two numbered air forces (3d Air Force and 17th Air Force), seven major operating bases, and 114 geographically separated locations (Tab CC-3 and CC-5).



(2) 48th Fighter Wing (RAF Lakenheath, UK)



The 48th Fighter Wing (48 FW), also dubbed “The Liberty Wing,” is located at RAF Lakenheath, UK, and is USAFE’s only F-15 fighter wing. The Wing is under the command responsibility of 3rd Air Force. Its mission is to provide responsive combat air power and support and services to meet United States (U.S.) and allied international objectives. Over the past decade, 48 FW has played a key role in antiterrorism operations, flying combat missions and providing combat support to U.S. and North Atlantic Treaty Organization (NATO) operations (Tabs CC-5 and CC-10).

The Liberty Wing consists of nearly 4,500 active-duty military members, 2,000 British and U.S. civilians, and includes a geographically-separated unit at nearby RAF Feltwell, UK. 48 FW is made up of three combat-ready squadrons of F-15E Strike Eagle and F-15C Eagle aircraft, as well as a Search and Rescue squadron equipped with the HH-60G Pavehawk helicopter. The Wing brings some of the most unique air combat capabilities to the fight, such as the most advanced Joint Direct Attack Munitions (JDAM) employed by the F-15E. In addition, 48 FW provides all-weather, day-or-night air superiority, air-to-ground precision combat capability, and multi-staged improvement program avionics (Tabs CC-5 and CC-10 to CC-11).

(3) 492d Fighter Squadron (RAF Lakenheath, UK)



The 492d Fighter Squadron (492 FS) is part of the 48 FW and operates out of RAF Lakenheath, UK. It is a combat-ready F-15E Strike Eagle squadron capable of executing strategic attack, interdiction, and counter air missions in support of USAFE, United States European Command (USEUCOM), and NATO operations. 492 FS provides responsive air combat capability while employing some of the most advanced technology, such as precision-guided weaponry and low altitude night targeting. The squadron deploys as the 492d Expeditionary Fighter Squadron, which stands combat-ready to respond to any theater of operations in the world (Tab CC-7 and CC-9 to CC-18).

(4) 48th Aircraft Maintenance Squadron / 494th Aircraft Maintenance Unit (RAF Lakenheath, UK)

The 48th Aircraft Maintenance Squadron (48 AMXS) of the 48 FW is a worldwide deployable squadron which conducts the inspection, generation and organizational maintenance of F-15E aircraft. It sustains two fighter squadrons in support of USAFE, USEUCOM, and NATO commitments through direction of two aircraft maintenance units (Tabs CC-10 and CC-19).



The 494th Aircraft Maintenance Unit (494 AMU) is a component of 48 AMXS specifically tasked with providing maintenance support to F-15E Strike Eagle fighters of the 494 FS. When deployed, 494 AMU becomes operational under the direct command responsibility of the Expeditionary Aircraft Maintenance Squadron commander (Tabs CC-10 and CC-11).

b. F-15E Strike Eagle

The F-15E Strike Eagle is a dual-role fighter with the capability to perform both air-to-air and air-to-ground missions. The F-15E's sophisticated avionics and electronics systems provide all-weather, day-or-night air superiority, air-to-ground precision combat capability, and multi-staged improvement program avionics (Tabs CC-57 and CC-61).



One of the most important characteristics of the F-15 "E" model is the rear cockpit from where a weapons system officer (WSO) monitors aircraft and weapons status and possible threats, selects targets, and navigates. The F-15E has two afterburning turbofan engines each capable of generating nearly 29,000 pounds of thrust and has the ability to carry up to 23,000 pounds of payload. The F-15E is also equipped with two low-drag conformal fuel tanks that can each carry 1,500 gallons of fuel. Each of the tanks hold weapons on short pylons rather than conventional weapon racks, reducing drag and further extending the range of the Strike Eagle. The fighter can carry most air-to-ground weapons, including JDAM and Standoff Land Attack Missiles-Extended Range (SLAM-ER), and it can be armed with air-to-air weapons, such as the AIM-120 Advanced Medium Range Air-to-Air Missile (AMRAAM), the AIM-9 Sidewinder, and Small Diameter Bomb (SDB). The "E" model also has an internally mounted 20 millimeter (mm) gun that can carry up to 500 rounds. For targeting, the F-15E employs the Low Altitude Night Targeting and Infrared Navigation (LANTIRN) system and Sniper Advanced Targeting Pod technology (Tabs CC-5, CC-57 to CC-58, and CC-61 to CC-62).

c. Operation ODYSSEY DAWN



On 19 March 2011, the U.S. and allied nations launched Operation ODYSSEY DAWN in support of a multilateral military effort to enforce United Nations (UN) Security Council Resolution 1973, adopted in response to the call to end the violence against the people of Libya by forces loyal to Libyan dictator Muammar al Qadhafi. The Resolution established a no-fly zone in Libyan airspace and authorized enforcement of a previously instituted UN arms embargo (Tabs CC-21, CC-24, and CC-26).

The Joint Task Force ODYSSEY DAWN (JTF-OD) was established to provide operational and tactical command and control of all U.S. military forces supporting Operation ODYSSEY DAWN. JTF-OD consisted of two component commands: the Joint Forces Air Component Command (JFACC), headquartered in Germany with U.S. Africa Command (AFRICOM), and the Joint Forces Maritime Component Command (JFMCC), led by the Commander, 6th Fleet, onboard the command ship *USS Mount Whitney* in the Mediterranean Sea. Strategic command responsibility was with AFRICOM's Army General Carter F. Ham, while tactical operations were coordinated under the command authority of Navy Admiral Samuel J. Locklear III. Nine NATO allies deployed and engaged military assets as part of Operation ODYSSEY DAWN (Tabs CC-21, CC-24, and CC-39).



In the initial stages, U.S. and coalition forces were quick to establish command of Libyan air space over some of its major cities, destroying portions of Libya's integrated air and missile defense system and attacking pro-Qadhafi forces deemed to pose a threat to civilians. U.S. aircraft involved in the operation included F-15s, F-16s, C-130Js, EC-130Js, C-5s, and P-3s. As of 28 March 2011, the U.S. had launched 192 Tomahawk cruise missiles from the Mediterranean Sea and had flown 983 sorties, 370 of which were bombing missions against pro-Qadhafi military sites and forces. The remaining sorties consisted of surveillance and refueling flights. Nearly 5,100 Sailors, Marines, Soldiers, Airmen and civilians were involved in Operation ODYSSEY DAWN (Tabs CC-29, CC-30, and CC-32 to CC-38).

On 27 March 2011, after a week of coalition air operations, NATO took command and control responsibility over all ongoing military operations enforcing UN Security Council Resolution 1973. The new operation, named Operation UNIFIED PROTECTOR, was commanded by Canadian Air Force Lieutenant General Charles Bouchard, and headquartered at Allied Joint Force Command in Naples, Italy (Tabs CC-26, CC-27, and CC-42).

4. SEQUENCE OF EVENTS

a. Mission

The mishap mission was tasked on 21 March 2011 by Operation ODYSSEY DAWN Air Tasking Order (ATO). The mission was a night combat strike sortie flying from Aviano AB, IT, to Libya. The mishap formation (MF) was loaded with both air-to-air and air-to-ground munitions for defensive and offensive operations (Tabs K-3, K-4, V-1.6, and V-1.7). Specifically, the MF was tasked to depart Aviano AB, IT, refuel from a KC-135 tanker en-route to the area of responsibility (AOR), and proceed to a designated hold point and wait for real-time taskings. To meet additional fuel needs, a KC-10 tanker was available near the AOR. Upon completion of the mission, the MF was to return to Aviano AB, IT (Tabs K-3, N-3, and R-8).

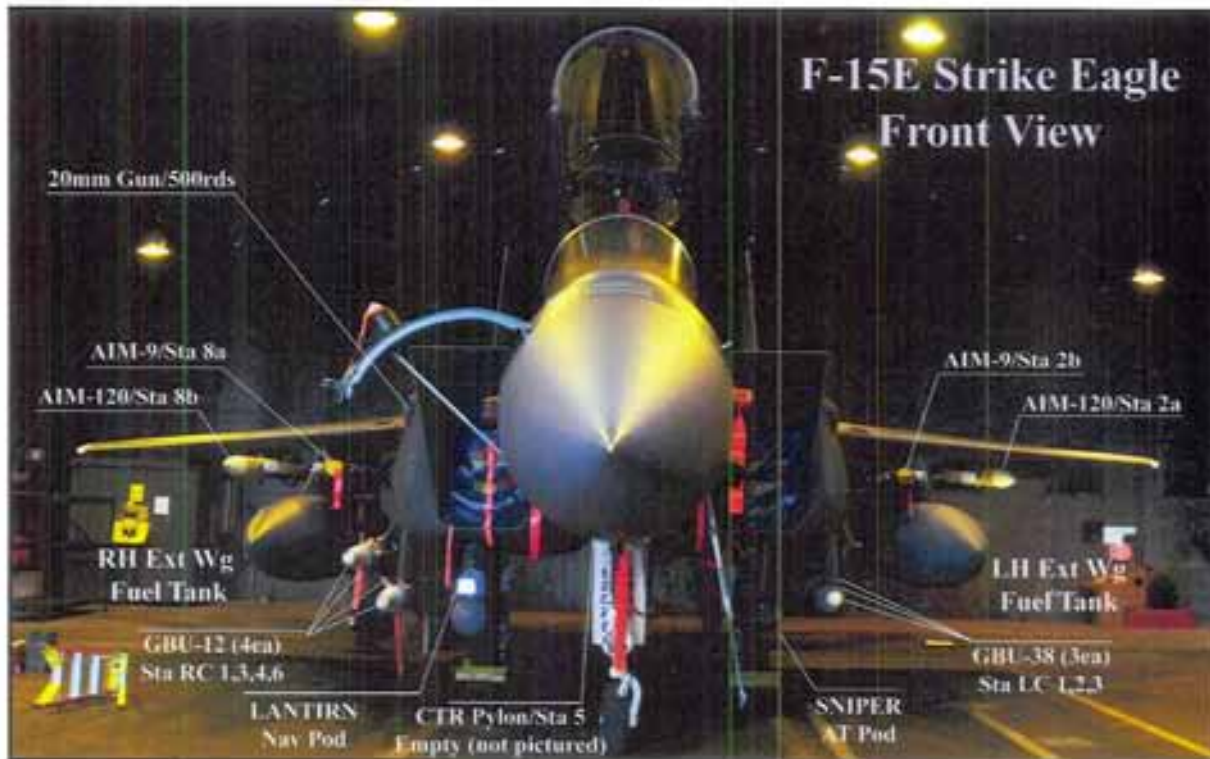
The MA, call-sign Bolar 34, was number two (wingman) of two F-15Es in formation. The MC consisted of the MP, Major [REDACTED], and the MW, [REDACTED]. The mishap formation lead aircraft (MFLA), also known as number one (#1), or under its call-sign Bolar 33, was operated by the mishap formation lead pilot (MFLP), Captain [REDACTED], and the mishap formation lead weapons system officer (MFLW), Lieutenant Colonel [REDACTED] (Tabs K-4, R-4, R-8, V-1.3, and V-2.3).

b. Planning

Mission planning and briefing was accomplished in accordance with (IAW) 492 EFS directives and standards. The briefing covered all mission objectives, intelligence assessments, mission execution, emergency and recovery procedures, special interest items, flight administration, training rules, as well as weather and Notices to Airmen (NOTAMS). The MFLW was the deployed squadron commander and represented supervisory interests. The MF was properly briefed and they fully understood their mission (Tabs R-4, R-8, V-1.6, and V-1.7).

In order to execute mission objectives, the MF was configured with two AIM-120s (outboard wing stations 2a, 8b), two AIM-9s (inboard wing stations 2b, 8a), two 610 gallon external fuel tanks (wing stations 2, 8), two 750 gallon Conformal Fuel Tanks (CFTs), Sniper Advanced Targeting Pod, LANTIRN Navigation Pod, three GBU-38s (Left Conformal stations 1/2/3), four GBU-12s (Right Conformal stations 1/3/4/6), 500 20mm rounds of ammunition, and centerline pylon not loaded with stores. The aircraft is inherently right wing heavy by 1,850 foot pounds (ft-lbs) due to the gun and its support equipment; with the added stores, the MA had a take-off lateral imbalance of 8,168 ft-lbs (Tabs V-1.7, V-1.14, V-2.6, V-4.6, AA-13 to AA-16).

The photographs below depict a front and back view of the F-15E's munitions configuration. Photographs were provided by the Air Force Public Affairs Office at RAF Lakenheath, UK. Labels and descriptions were added by the AIB based on witness and documentary evidence.



c. Preflight

At approximately 1600Z, an hour before scheduled mission takeoff, the MC received their step briefing from the squadron operations supervisor and proceeded to their aircraft. The step briefing is the final preflight briefing given by squadron supervisors. Content of the briefing included aircraft status, updates to weather, airfield status, and items of interest related to the pilot's planned mission (Tabs R-4, R-8, V-1.6, V-1.7, V-2.6, V-2.7, V-4.5 to V-4.8). The MC performed all preflight checks IAW appropriate technical orders. The aircraft was loaded with external stores (munitions, pylons, and fuel tanks) as expected from pre-mission planning. All the required pre-taxi checks were accomplished. Minor discrepancies in the Automatic Flight Control System (AFCS) and hydraulic system were identified and corrected prior to taxi. Cryptological code re-keying for mission essential systems was also accomplished prior to taxi. With all three systems meeting preflight technical order (T.O.) requirements, the MC taxied without incident (Tabs R-4, R-8, V-1.6, and V-4.8).

d. Summary of Accident

At 1713Z, the MF took off from Aviano AB, IT. Enroute to the AOR, the MA's master caution light illuminated twice. Both times the master caution indicated "FLT CNTRL" (flight control) advisory. In both instances the advisory cleared automatically with no loss of AFCS functionality. The MP attributed each occurrence to brute force disconnect of the auto-pilot and determined the aircraft had no malfunctions. Brute force disconnect is defined as manually applying control stick pressure to override and disengage the auto-pilot (Tabs R-4 and R-8).

The MF refueled uneventfully from a KC-135 tanker enroute to Libya and arrived on-station in the AOR at its hold position as scheduled. While holding position, the MFLA observed Anti Aircraft Artillery (AAA) being fired in their direction and maneuvered away. Command and control then tasked the MF with specific targeting. The MF refueled uneventfully from a KC-10 and departed for its mission tasking at 2104Z (Tabs R-4, R-8, R-36, R-39, R-47, V-1.7, V-1.10, V-1.11, and V-1.16).

At 2109Z, while staging for the mission tasking, the MC relayed "right external tank is not feeding" to the MFLA. The MC requested permission to descend to 20,000 feet (ft) mean sea level (MSL) in an attempt to cause a pressurization change and force the fuel to feed. At 20,000 ft MSL, the MA's right external tank started feeding immediately and the MA climbed back up to 30,000 ft MSL. As the MC mapped the target, they took a final look at the right external tank and stated fuel was feeding slowly with 2,500 pounds (lbs) remaining and left external tank empty. At 2112Z, the MC communicated again to the MFLA that the trapped fuel was "feeding, it's just slow" and asked if they were "just going to tuck tail and run right" after releasing munitions (Tab N-3, N-4, R-37, V-1.12 to V-1.14, V-2.8, and V-2.9). The attack formation was planned to be tactical line abreast with MFLA on the left and both aircraft exiting the target area via left hand turns, returning to formation after egress (Tabs R-4, R-40, and R-48).

At 2119Z, the MF armed weapons and began the target run in the 30-32,000 ft MSL altitude block at Mach 0.9. The MA pushed forward in the formation approximately two miles ahead of the formation lead, which placed the MA at the weapon release point sooner than the MFLA

(Tabs N-4, R-4, and AA-3). The MF initially planned a left turn egress after weapons release, however, due to the MA's forward position in the formation, at 2127Z, the MFLP directed the MC to depart the target area via a right-hand turn. Doing so would ensure the MA would not fly directly through the MFLA's flight/weapon path after its weapons release. Although expected to release weapons and start its turn first, the MC was delayed in doing so. As a result, both aircraft released weapons and started their corresponding turns away from each other near simultaneously. The MFLA crew assumed the MC had some issues releasing weapons but had sufficient range to affect a good release (Tabs N-4, R-4, R-40, and R-48).

The MF's specific tasking required employment of GBU-38s, which were loaded on their left conformal fuel tank stations (i.e. LC 1, LC 2, and LC 3). Per tasking requirements, the MW selected a GBU-38 from the MA's left conformal fuel tank station one (LC 1) and transferred target data into the weapon. After verifying loaded target data and confirming the weapon was ready, the MC verbalized the weapon was ready for release. The MC released the weapon just after passing over the coastal area near the target. With release of the weapon, the MC felt a "thump" and both checked the smart weapons display to confirm the GBU-38 had released. Weapon release from LC 1 increased the MA's lateral asymmetry to at least 11,275 ft-lbs right wing heavy. Two to three seconds after release, in an attempt to maintain airspeed and avoid known threats, the MP initiated a slightly descending right hand exit turn from the target area using approximately a 100 degree bank, military power setting (full power without afterburner), and 330 knots/0.85 Mach. 90 degrees through the turn, the nose of the aircraft fell, and the MP reduced control stick back pressure in an attempt to reduce aerodynamic forces. The MA subsequently departed controlled flight developing into a left hand spin about the vertical axis (Tabs M-3, M-4, N-4, R-4, R-8, R-37, R-39, R-40, and AA-3).

At 2128Z, the MA made a radio call stating "#2's in a spin" (Tab N-4). MFLA crew initially understood the call to mean the MC would be attempting target re-attack ("spin" is a communications brevity word describing an aircraft is or needs maneuvering to reposition itself to an earlier phase of flight). Unsure if the MA released a weapon, the MFLA crew discussed the MA weapon impact time and queried the MC "2, say time to impact" to which the MC replied "2's in a spin. Mayday, mayday, mayday" (Tabs N-4 and R-48).

As the departure developed, the MP initiated recovery from what the MA indicated was a full left spin. The MW confirmed flight controls were set as directed by spin recovery displays, noted the audible "Yaw Rate" and "Over-G" warnings, and then began calling out altitudes as the MA continued to lose altitude. Passing through 12,000 ft MSL, the MW observed the spin slow slightly then accelerate again with maximum pitch attitude change of +/- 5 degrees off the horizon. Reaching uncontrolled bailout altitude, the MP commanded "Bailout, Bailout, Bailout," and initiated the ejection sequence. The MP observed speed of 14 knots and altitude of 5,715 ft above ground level (AGL) as his seat departed the MA (Tabs M-3, M-4, N-4, R-4, R-8, and AA-3).

e. Impact

The MA impacted the ground at approximately 2129Z in an unpopulated area near Benghazi, Libya and was destroyed. Photographs from the impact site indicate the MA struck the ground flat with near zero forward velocity and significant left rotation. This damage to the MA is consistent with a left flat spin. There were no known civilian casualties or additional damage at impact (Tabs M-3, M-4, N-4, P-5, and S-4 to S-18).

Front View of Mishap Aircraft's Nose Section



The photograph shows the MA impacted the ground in a spin. This is apparent from the fact that the length of the MA is not significantly compressed, the aircraft nose is compressed flat on the ground, and the ground around the nose section is not cratered or significantly scarred.

Back View of Mishap Aircraft on Impact



The photograph shows the MA was rotating left upon impact. The flat left spin rotation is evident from (1) the tops of the vertical tails which are mainly intact; (2) the compressed engine nozzles; and (3) the soil covering the right horizontal stab.

f. Egress and Aircrew Flight Equipment

The MC ejected safely from the MA. There is no evidence to determine if the MC was using Night Vision Goggles (NVGs) at the time of ejection. Due to the location of the mishap, it was not possible to examine any egress components but the Advanced Concept Ejection Seat II (ACES II) seats functioned properly as both crew members had fully inflated parachutes and suffered only minor injuries upon landing (Tabs P-5, R-5, R-8, R-21, R-103, and X-3).

After the ejection, the MP identified the left four-line jettison handle was missing from the ACES II recovery parachute and the life raft became tangled around his leg during descent. The MP was able to untangle the raft and did not experience further problems (Tab H-6, R-5, and V-3.5).

The MW identified the same defect of the left four-line jettison handle missing. In addition, the MW experienced two additional malfunctions, one being twisted risers which he successfully corrected, and the other an 80% tear in the parachute canopy panel. The MW suffered a sprained knee upon landing (Tabs P-5, R-8, R-31, V-4.10, and X-3).

g. Search and Rescue

After landing, the MP doffed his equipment, grabbed the hit-and-run kit (small survival kit) and began evasion/isolated personnel procedures. The MC was contacted within 15 minutes of aircraft egress. The MP evaded for three hours before being picked up by friendly forces and transported to the *USS Kearsarge*. The MW was also recovered by friendly forces shortly after the mishap (Tabs R-5, V-3.5, V-3.6 and V-4.10).

5. MAINTENANCE

a. Forms Documentation

(1) General Definitions

Air Force aircraft maintenance and inspection histories are documented on Air Force Technical Order (AFTO) 781 series forms and in a computer database known as Integrated Maintenance Data System (IMDS). In addition to scheduling and documenting routine maintenance actions, these tools allow aircrew to report aircraft discrepancies, and maintenance personnel to document the actions taken to resolve them. Additionally, they provide a tool to research past aircraft problems to more effectively troubleshoot and solve new maintenance discrepancies (Tabs D-3 to D-54, D-60 to D-68, U-3, U-15, U-19 to U-39, and AA-17).

Time Compliance Technical Orders (TCTO) are used to process system changes, usually aircraft part upgrades, which must be accomplished within a specific time period and by a specific date depending on the severity of the issue. A TCTO may also direct inspections or adjustments to equipment or parts already installed on the aircraft. Time change items are routine maintenance actions in which components are removed and replaced at a given number of flight hours or calendar days (Tabs D-24, U-10, and AA-17).

(2) General Documentation Reviewed

A thorough review of the available MA maintenance documentation was conducted. This review consisted primarily of the IMDS data that was captured shortly after the mishap, and which reflects maintenance conducted up to 90 days prior to the mishap. Also reviewed were the AFTO 781 series forms for the MA collected after the incident. These forms documented maintenance conducted on the day of the mishap and reflected a signed exceptional release indicating the aircraft was airworthy and that maintenance had released it to the MC for flight. No discrepancies relevant to this mishap were found in the reviewed maintenance documentation (Tabs D-24 to D-49, U-19 to U-39, and AA-17).

There were no overdue TCTOs, time change items, or special inspections at the time of the mishap. IMDS reflected one grounding discrepancy, which was not cleared electronically due to computer network limitations at the deployed location. However, AFTO 781A forms properly indicated the airworthiness of the MA. Maintenance pre-flight and basic post flight/preflight combination inspections are documented on the AFTO Form 781H. The exceptional release for the aircraft and the basic postflight/pre-flight inspection were properly documented, indicating that the MA had a valid pre-flight inspection prior to the mishap sortie. According to witness

statements, procedural requirements were followed at all times which would have prevented the release of a non-airworthy aircraft for flight (Tabs D-24 to D-49, U-19 to U-39, V-5.5, V-5.11, V-5.15, and AA-17).

(3) Documentation Specific to the Automatic Flight Control System (AFCS)

A 90 day review of IMDS and Data Transfer Module (DTM) data for the MA, which contains historical diagnostic and fault reported data, revealed multiple lateral stick limit (LAT STK LMT) advisories on 11 and 15 March 2011 on the aircraft's AFCS (Tabs D-27, D-41, U-19 to U-25, and U-39). Witness statements indicate that the MA experienced additional LAT STK LMT advisories during two previously flown sorties shortly before the incident on 19 and 20 March 2011. Those advisories, however, were not downloaded due to unavailability of Local Area Network (LAN) connectivity at the deployed location. As a result, it is not known if the 11 and 15 March 2011 DTM data related to the LAT STK LMT advisories observed on 19 and 20 March 2011 (Tabs L-3 to L-5, V- 5.9, V-5.16, and DD-16 to DD-26).

LAT STK LMT is a functional indicator of potentially degraded AFCS components. The AFCS is the electrical portion of the electro-hydro-mechanical flight control system, which allows digital input to the flight control system providing flight control augmentation, autopilot and terrain following control, and spin recovery differential stabilator control. An actual LAT STK LMT fault would indicate degradation of the lateral control portion of the AFCS. This would require the pilot to limit lateral control inputs to half stick displacement. During all LAT STK LMT advisories on the MA, the pilot's function page did not display actual loss of function and the aircraft remained fully operational (Tabs V-5.7, AA-19, and DD-17 to DD-19).

On 20 March 2011, maintenance personnel replaced the MA's Flight Control Computer (FCC) to troubleshoot the aircraft's multiple LAT STK LMT advisories. An AFCS maintenance built-in test (M-BIT) check was performed as part of the operational verification after replacing the FCC on the MA. The aircraft was returned to service with no defects noted. In the 90 days preceding the mishap, no other AFCS issues were noted (Tabs D-3 to D-65, D-68, D-69, U-3, AA-17, and AA-19).

b. Inspections

Normally scheduled inspections on the MA were completed and documented in accordance with applicable technical orders. There were minor discrepancies noted, however, they were not a factor to the incident. A review of the maintenance records for the equipment used to service the aircraft was also accomplished, and there were no overdue inspections (Tabs D-3 to D-65, U-19, U-25, AA-17, and AA-21).

(1) Aircraft Inspections

The phase inspection process for the F-15E is conducted on a 1,200-hour cycle, broken into three 400-hour phases. An hourly post-flight inspection is conducted at 400 hours (Phase #1), which is repeated again at 800 hours (Phase #2), followed by a more comprehensive periodic inspection at 1,200 hours (Periodic Inspection); then the inspection cycle repeats. The inspections are completed by phase-inspection teams composed of Crew Chiefs, Avionics, and Flight Control Specialists. The phases consist of removing panels and inspecting aircraft systems for correct

operation, as well as checking flight control surfaces for proper rigging, and to ensure no water is trapped in flight control surfaces. The last phase inspection on the MA was completed at 4,819.6 flight hours on 12 November 2009. At the time of the mishap, the MA had 5,105.2 flight hours and was due its next phase inspection at 5,219.6 flight hours. The F-15E also undergoes programmed depot maintenance, a major overhaul inspection, every six years (Tabs D-24, D-66, U-25, U-39, and AA-17).

(2) Engine Inspections

The F-15E engine inlet and engine exhaust are inspected visually prior to and after every sortie and before and after every engine run. Each engine is inspected internally every 100 hours and engine components with specific time change requirements are verified daily. The MA's #1 (left) engine was installed on 19 November 2010 and the #2 (right) engine was installed on 24 September 2009. The #1 engine had flown 101.5 hours since its installation on the MA and totaled 6,390.8 operating hours. The #2 engine had flown 371.6 hours since installation with a total of 4,763.1 operating hours. Line Replaceable Units (LRUs) and Shop Replaceable Units (SRUs) are engine components and modules, which have limited lifetimes tracked by hours or cycles and are checked daily to verify serviceability. Removal of the engine plugs and covers, as well as engine intake/exhaust foreign object damage (FOD) inspection were conducted prior to the mishap sortie. All scheduled inspections were completed on time and there were no overdue inspections or modifications (Tabs D-13, D-20 to D-24, D-28, D-32, D-34, D-36, D-37, D-49 to D-51, and AA-17).

c. Maintenance Procedures

Maintenance procedures on the MA were performed in accordance with applicable TOs and AFIs at the time of the mishap, except for minor IMDS documentation discrepancies which were not causal or contributory to this mishap (Tabs D-3 to D-65 and AA-17 to AA-21).

(1) AFCS Maintenance Procedures

Maintenance procedures specific to the AFCS require personnel to be trained and qualified in theory of operation, tracing system diagrams, performing operational checkouts, isolating malfunctions, and LRU removal and installation. Further, 781 series forms documentation must reflect all maintenance actions conducted on an aircraft's AFCS (Tabs D-24, D-39, V-5.6, and AA-21).

(2) Discrepancies with AFCS Maintenance Procedures

Evidence indicates that the maintenance member performing the FCC installation was not qualified to perform the task. The member was in training at the time of the incident but had no start date in his training record. Further, the Avionics Expeditor, who inspected the FCC installation, signed off the red X entry as complete without identifying that two power connectors were reversed. A red X entry indicates an unsafe or unserviceable condition in which the aircraft may not be flown until the condition is corrected (Tabs V-3.3, V-5.6, V-11.3, and V-15.9). This discrepancy, however, was corrected by the day-shift FCC operational check-out conducted on the MA prior to the mishap sortie taking off. And finally, another minor procedural discrepancy involved failure to document FCC removal from cannibalized aircraft. The FCC is a serial number controlled LRU, which requires entry into IMDS. However, no such

entry occurred due to computer network limitations at the deployed location. None of these minor administrative discrepancies contributed to the mishap (Tabs D-39, G-31, R-12, R-15, R-63, R-66, R-82, R-86, and R-89).

FCC Channel Power Connectors



The photo above shows properly configured FCC connections. Of note, the A, B, and C channel power connectors all have the same connector/receptacle key configuration. The B and C connectors are often mistakenly reversed during installation due to the matching connector/receptacle key configuration and the close proximity to each other.

d. Maintenance Personnel and Supervision

Active duty military personnel of 494 AMU maintained the MA. Aircraft maintenance records and statements from maintenance personnel indicated that pre-flight and launch activities relating to the mishap sortie were normal and ultimately performed by the appropriate personnel and with the required supervision. Training records and the special certification roster of the 494 AMU reflect that the overall maintenance performed on the aircraft was completed by fully qualified maintenance personnel. Additional records review, however, revealed that maintenance specific to the AFCS was performed by a technician in training. The Avionics Specialist in training did not have a start or completion date in his training record. Due to unavailability of engine run qualified personnel on shift, the required M-BIT check could not be completed until the following shift. As a result, the installation error with the FCC was corrected when the day-shift Avionics Specialist conducted the M-BIT check. Aircraft records and witness statements indicate that once the error was corrected, the aircraft checked out fully operational and airworthy (Tabs D- 39, G-31, D-62, D-65, R-12, R-18, R-59 to R-64, R-67 to R-71, R-83 to

R-89, R-91 to R-95, R-98 to R-100, and AA-17). These minor errors were not contributory to the mishap.

In addition, review of Aircrew Flight Equipment (AFE) records revealed the parachute rigger, who inspected and repacked both ACES II recovery parachutes on the MA, was overdue annual recertification. His recertification was due on 15 September 2009 (Tabs H-4, and H-7 to H-12). This discrepancy was not a factor to the mishap.

e. Fuel, Hydraulic Fluids, and Engine Oil Inspection Analysis

Following the mishap, fuel, hydraulic fluid, and engine oil samples were taken from the fuel truck, hydraulic cart, and oil cart that serviced the MA. Each sample was found to be unremarkable (Tabs D-52 to D-59). Petroleum, hydraulic, or engine oil anomalies were not a factor to the mishap.

f. Unscheduled Maintenance

Review of the 90-day history in IMDS reflected several unscheduled maintenance actions relating to a fuel leak, targeting pod, video tape recording system, navigation pod, left main gear tire and others for the MA, none of which were considered relevant to the mishap (Tabs D-41, L-3 to L-19, and U-19). DTM data displayed history of AFCS LAT STK LMT advisories from 11 and 15 March 2011, however, this data was not entered into IMDS as an event. The aircraft flew sorties on 19 and 20 March 2011 en-route to Aviano AB, IT, with additional AFCS LAT STK LMT advisories. Maintenance personnel performed unscheduled maintenance for the LAT STK LMT discrepancy on 20 March 2011 by replacing the FCC (Tabs D-27 to D-40, D-50, D-51, D-60, and DD-13).

6. AIRCRAFT AND AIRFRAME SYSTEMS

a. Affected Aircraft and Airframe Systems

Upon crashing, the aircraft was completely destroyed and deemed unrecoverable. There is no evidence to indicate that mechanical or other system failures contributed to the mishap (Tabs S-4 to S-18).

b. Condition of Systems

The MA was destroyed on impact and physical aircraft wreckage was unrecoverable. As a result, it was not possible to assess the condition of specific systems and components from the MA (Tabs S-4 to S-18).

c. Testing and Analysis

Since the MA was destroyed on impact and no on-board flight data recordings could be obtained, systems testing and analysis was limited to crash site photo evidence and simulator evaluation of flight characteristics using MA configuration data.

(1) Aircraft Components and Systems of Interest

The external fuel system design of the F-15E leaves it susceptible to producing external wing tank fuel imbalances that can leave the aircraft extremely susceptible to departing controlled flight. The F-15E uses differential pressure to transfer fuel from the external wing fuel tanks to the internal wing fuel tanks. The total pressure at each wing tank can vary, and, as a result of this variation, both external wing tanks may not transfer at the same rate, resulting in a fuel imbalance. Air-to-air refueling requires depressurization of the external tanks. Once refueling is complete the tanks are re-pressurized. It is not uncommon for the F-15E to experience external fuel transfer problems after air-to-air refueling as a result of this cycle. It is not known if the reported fuel imbalance still existed at the time of the mishap (Tabs R-38, V-1.12 to V-1.14, V-4.14, and DD-17).

The basic empty F-15E is laterally imbalanced with a moment of 1,850 ft-lbs right-wing heavy due to the internal gun and other aircraft installed equipment. A moment is a measurement used in calculating aircraft weight and balance. Loading of external stores has a marked effect on the aircraft's lateral asymmetry depending on the configuration loaded. Using the known stores configuration at the time the MA launched, it was possible to calculate the take-off lateral imbalance of the MA at 8,168 ft-lbs right wing heavy (Tabs U-5 to U-16, and AA-13).

With fuel in the external fuel tanks and/or air-to-ground stores loaded, the F-15E is limited by technical order to a maximum angle of attack (AOA) of 30 cockpit units (CPU) (Tab BB-13). AOA is the angle between the relative wind direction and the aircraft wing cord line. The F-15E does not directly display AOA. Instead, it displays AOA as CPUs, which is actual AOA plus 10 degrees. The aircraft has a programmable high AOA warning tone the pilot can set from 20 to 45 CPUs. The default setting is 30 CPUs. The warning tone beeps to cue the aircrew when the programmed AOA is exceeded. The aircraft can attain AOA in excess of the maximum displayed 45 CPUs. Normal maneuvering range is from approximately 8 to 30 CPUs. High AOA is considered to be above 30 CPUs. The F-15E's 30 CPU restriction was put in place to mitigate the risk of departure (uncontrolled flight path change) due to imbalanced fuel in the external fuel tanks (Tabs AA-7, AA-9, and AA-13).

(2) Simulator Evaluation

Simulator evaluation was conducted in the F-15E Mission Training Center (MTC) ground based simulator at RAF Lakenheath, UK, on 8 July 2011. The F-15E simulator is a stationary clamshell simulator with a projection screen that provides 360 degrees of horizontal and approximately 120 degrees of vertical view. The simulator is capable of presenting a variety of emergency, normal flying, and combat operations situations (Tab AA-13).

Since no data was recovered for analysis, parameters for simulator evaluation were derived from witness statements and aircraft documentation. The exact altitude, airspeed, AOA, and fuel load for the MA were not available. Available evidence indicated the MA was at approximately 32,000 ft MSL and 0.9M when the MP initiated a 90-100 degree angle of bank turn. The last known parameters were 330 knots and Mach 0.85 during the first part of the turn (Tabs R-4, R-8, R-37, and R-38). The MP reports the aircraft's nose dropped once approximately 90 degrees through the 180 degree right turn; the aircraft stopped responding to flight control inputs and

then abruptly departed controlled flight, entering a left spin. The simulator tests were planned using these entry parameters, as well as the MA's known external stores configuration, and varying data accounting for a possible fuel imbalance up to a maximum of 2,500 lbs right wing heavy (the maximum fuel imbalance having been 2,500 lbs right wing heavy) (Tabs R-4 and R-8). The F-15E TO 1F-15E-1-2-1, *Flight Manual* (Dash 1), dated 1 July 2009, states any lateral imbalance is controllable up to and including 30 CPU of AOA. Contrary to the Dash 1 and aircrew understanding, the simulator entered a spin at 26 CPU (Tabs R-38, R-52, V-1.14, V-2.6, AA-3, AA-9, and AA-13 to AA-16). This premature departure from controlled flight raised controllability concerns with lateral imbalances. The AIB expanded the evaluation parameters to quantify simulator departure susceptibility.

The expanded simulator evaluation examined a matrix of possible ranges of altitude, AOA, and fuel imbalance around the MA's flight parameters. Starting airspeed was varied across a small window (0.9M to 0.915M) to approximate possible deviations and offer design variability (since exact MA airspeed was not known and to explore the sensitivities of the simulator around MA airspeed window). The AIB evaluated simulator performance at 32,000 ft, 30,000 ft, 25,000 ft, and 20,000 ft MSL. There were nine possible configurations examined within these initial parameters. These nine configurations consisted of stores and fuel changes. Specifically, weapons were varied (1) as loaded at takeoff, (2) after releasing one GBU-38 (as done during the mishap sortie), and (3) if the aircraft were to have been tasked to release two GBU-38s. These three weapons configurations were evaluated under three different fuel imbalances: (1) 2,500 lbs right wing heavy as witnessed prior to the release; (2) 1,250 lbs right wing heavy as an approximation of moderate imbalance; and (3) zero imbalance (or fuel balanced). Each data point was duplicated three times (Tabs R-4, R-8, and AA-13 to AA-16).

Boeing designs its MTCs to be more susceptible to spinning in one direction. The RAF Lakenheath MTC was designed to be more prone to spinning right (opposite of the mishap). Therefore, the majority of the test envelope was designed around a mirror image of the MA configuration flown on 21 March 2011 (minus the internal gun which could not be changed thus slightly reducing the overall imbalance). As a point of verification, the MA's exact configuration was then duplicated to capture data points. **It is important to note, the simulator is not an exact replication of the MA, but a simulation of a notional F-15E with a similar configuration and with consideration given to simulator design** (Tab AA-13).

Airspeed was a significant factor in simulator performance. The planned AOAs represent an energy bleeding (decelerating) condition for an F-15E. Therefore, as the turn progressed the airspeed decreased. There was a significant susceptibility to depart as the simulator decelerated through 0.82M, even though it was flying as expected prior to departure. It is very important to note that the simulator would enter a spin at AOA less than 30 CPUs (Tabs AA-15 to AA-16).

LAKENHEATH F-15E SIMULATOR SPIN STABILITY

Left Asymmetry

FUEL IMBALANCE (lbs)		2500 lbs			1250 lbs			0 lbs		
AOA (CPU)		35 CPU	30 CPU	25 CPU	35 CPU	30 CPU	25 CPU	35 CPU	30 CPU	25 CPU
ALTITUDE	CONFIGURATION									
MSL										
32K ft	DROP 2: 4 x 1	28°	24°	25°	30	30	25	35	30	25
	OFF TGT: 4 x 2	25°	21°	25°	32	30	25	35	25	25
	T/O: 4 x 3	25°	21°	25	32	30	25°	35	30	25
30K ft	DROP 2: 4 x 1	28°	24°	27°	30	30	25	34	30	25
	OFF TGT: 4 x 2	26°	24°	25°	30	30°	25°	35	30	25
	T/O: 4 x 3	27°	27°	25	30°	30	25	35#	30	25
25K ft	DROP 2: 4 x 1	25°	20°	25	28	28	25°	350	30	25
	OFF TGT: 4 x 2	25°	20°	25	29°	30	25°	360	30	25
	T/O: 4 x 3	25°	20°	26	34	30	25°	361	30	25
20K ft	DROP 2: 4 x 1	25°	20°	25	33	28°	25°	362	30	25
	OFF TGT: 4 x 2	23°	20°	25	34	30	25°	363	30	25
	T/O: 4 x 3	23°	20°	25	34	30	25	364	30	25

Right Asymmetry

FUEL IMBALANCE (lbs)		2500 lbs			1250 lbs			0 lbs		
AOA (CPU)		35 CPU	30 CPU	25 CPU	35 CPU	30 CPU	25 CPU	35 CPU	30 CPU	25 CPU
ALTITUDE	CONFIGURATION									
MSL										
32K ft	DROP 2: 4 x 1									
	OFF TGT: 4 x 2	28°	24°	25	30	30	25	35	30	20
	T/O: 4 x 3									
30K ft	DROP 2: 4 x 1									
	OFF TGT: 4 x 2	28°	24°	24°	33	30°	25°			
	T/O: 4 x 3									
25K ft	DROP 2: 4 x 1									
	OFF TGT: 4 x 2									
	T/O: 4 x 3									
20K ft	DROP 2: 4 x 1									
	OFF TGT: 4 x 2									
	T/O: 4 x 3									

RED = Spin YELLOW = Adverse Roll Off GREEN = Predictable/Normal Response
 Numbers = CPU Angle of Attack at First Indication (approximate due to overshoot & display)

- 1 Immediate spin with little chance of recovery at depicted AOA
- 2 Designated CPU turn--as airspeed decreases through Mach 0.82, sim immediately exhibits adverse roll to spin
- 3 Adverse roll as depicted but if controls not immediately neutralized, sim would enter spin
- 4 Sim exhibited adverse roll and enter spin with high yaw rate and little indication of recovery
- 5 Sim exhibited adverse roll and enter spin with low yaw rate and could recover near immediately
- 6 At 30 CPU adverse yaw then snapped into a spin at 32 CPU
- 7 Designated CPU turn--as airspeed decreases through Mach 0.82 sim exhibited controllable adverse roll

Left Asymmetry Config	A/A: 2xAIM-120 [2A/8B], 2xAIM-9M [2B/8A] A/G: 3xGBU-38 [RC 1/2/3], 4xGBU-12 [LC 1/3/4/6], Sniper, Lantirn, Gun
DROP 2: 4 x 1	10322.55 ft-lb lateral asymmetry left*--Dropped 2x GBU-38 [LC 1/2] --fuel independent
OFF TGT: 4 x 2	7216.2 ft-lb lateral asymmetry left*--Dropped GBU-38 [LC 1] --fuel independent
T/O: 4 x 3	4109.85 ft-lb lateral asymmetry left* --fuel independent
	*Store values and asymmetry calculations based on T.O. 1F-15E-1-2-1 (1 Jul 09)
Right Asymmetry Config	A/A: 2xAIM-120 [2A/8B], 2xAIM-9M [2B/8A] A/G: 3xGBU-38 [LC 1/2/3], 4xGBU-12 [RC 1/3/4/6], Sniper, Lantirn, Gun
DROP 2: 4 x 1	14381.35 ft-lb lateral asymmetry right*--Dropped 2 x GBU-38 [LC 1/2] --fuel independent
OFF TGT: 4 x 2	11275 ft-lb lateral asymmetry right*--Dropped GBU-38 [LC 1] --fuel independent
T/O: 4 x 3	8168.65 ft-lb lateral asymmetry right* --fuel independent
	*Store values and asymmetry calculations based on T.O. 1F-15E-1-2-1 (1 Jul 09)

ENTRY CONDITIONS 0.9 Mach, Wings level; right hand turn, angle of bank to maintain AOA, Symmetrical turn unless otherwise noted

FUEL IMBALANCE (lbs) Differential amount of fuel in pounds between the external tanks
 AOA (CPU) Angle of Attack (AOA)--CockPit Units (CPU). Equal to aircraft AOA plus 10.
 ALTITUDE (ft) Feet above Mean Sea Level (MSL)

The chart above is a product of the AIB and the parameters used for the simulations conducted were based on available factual evidence and witness statements obtained in the course of the investigation. In the second table above, the bottom left number of 28¹ represents a right laterally asymmetric simulator with off-target air-to-air (A/A) stores of 2x AIM-120 and 2x AIM-9M; air-to-ground (A/G) stores of 2x GBU-38 and 4x GBU-12; plus pods, gun, and a right external fuel imbalance of 2,500 lbs. The 28¹ signifies that the aircraft entered a spin at 28 CPU and the superscript "1" indicates that the simulator entered into an immediate spin with little chance of recovery at the particular AOA used (Tabs AA-14 to AA-16).

The left asymmetry table shows the simulator parameters flown with the external stores mirror-imaged (since the simulator spin tendency is opposite of the actual MA). The right asymmetry chart shows the simulator parameters configured the same as the MA. Both configurations were tested under AOAs varying from 35 to 25 CPU, and external fuel imbalance ranging from 2,500 lbs to 0 lbs (balanced). The simulator exhibited very stable flight characteristics at 32,000 ft MSL with 0 lbs fuel imbalance, therefore, MA's configuration at 30,000 ft MSL with 0 lbs fuel imbalance was not tested (Tabs AA-14 and AA-15).

The tables capture the simulator findings and the footnotes detail notable simulator characteristics. The top chart displays tested parameters in more detail due to known simulator left bias. The bottom chart represents simulator testing with the actual MA configuration (in mirror image). The green color was used to indicate predictable departure characteristics with typical control response; yellow represents departure as an abrupt maneuver from intended flight; red indicated that the simulator entered uncontrollable spin (Tabs AA-14 and AA-15).

Simulator evaluation showed conclusive evidence of a finite AOA where the simulator lost directional controllability (i.e. the simulator stalled) under varying lateral asymmetries. For consistency, this AOA is referred to as Critical AOA. Dash 1 guidance claims full controllability at AOA of 30 CPUs or less; however, simulator evaluation proved this to be erroneous. It is evident the MA exceeded its Critical AOA, which may have been even lower than the published Dash 1 limit (Tabs AA-9, AA-13 to AA-16).

The Dash 1 prohibits maneuvering at AOA above 30 CPUs with external tanks and lateral asymmetries above 5,000 ft-lbs. The simulator evaluation showed that more severe lateral asymmetries result in departure from controlled flight at lower AOAs. The Dash 1 does not provide clear (Note, Warning, or Caution) guidance that directional-lateral stability progressively decreases as lateral asymmetry increases (Tab AA-9).

Due to the combat nature of the mission, the MA was configured with the maximum amount of munitions. The MA's configuration of three GBU-38s and four GBU-12s allowed maximum combat lethality. The F-15E Suite 6E (S6E) Operational Flight Program (OFP) software has a known deficiency with the right CFT step-over function. The step-over function gives aircrew the ability to bypass (or "step-over") a failed munition and release the next one in sequence. The S6E anomaly does not allow this function to operate as designed on the right CFT. If a munition in sequence malfunctions from the right CFT, it cannot be bypassed to release the next munition

in sequence. Loading the MA with three GBU-38s on the left CFT and four GBU-12s on the right CFT allowed the MC to potentially employ the remaining GBU-38s if the first in sequence failed. This configuration resulted in a lateral asymmetry of 8,168 ft-lb at takeoff due to the S6E OFP deficiency (Tab AA-5).

When the MC released the GBU-38 from the LC 1 station, the resulting lateral imbalance grew to 11,275 ft-lbs (Tab AA-15). Assuming worst case scenario conditions, the MA's stores imbalance combined with a 2,500 lb fuel imbalance could have resulted in a lateral asymmetry of 35,275 ft-lbs right wing heavy. Prior to the mission, the MF crews were not aware of the reduced operational performance margin as it related to the severity of the takeoff imbalance and the additional imbalance generated by munition release (Tabs R-53, R-56, V-1.14, V-2.11, and V-4.15).

Additionally, no data has been published that defines F-15E combat loaded performance/maneuverability at high altitudes of 30,000 ft MSL and higher. The performance/maneuverability charts from the F-15E Combat Aircraft Fundamentals Manual (AFTTP 3-3.F-15E) show aircraft specific energy (P_s) charts for 5,000 ft, 15,000 ft, and 25,000 ft MSL only (Tabs AA-7 and AA-9). The simulator performed notably poorer as altitude increased. Specifically, the simulator showed that even at 25,000 ft MSL, it could abruptly enter a spin at AOA as low as 26 CPU (Tab AA-15). However such data had not been published at the time of the mishap, therefore these characteristics likely would not have been known or understood by the MC (Tabs V-4.15 and AA-11)

There was limited data available to describe the spin recovery techniques taken by the MC. In the simulator, recovery was not always possible at the higher limits of lateral asymmetry and was severely degraded, if not impossible, when the Control Augmentation System (CAS), an electronic flight control system that improves aircraft handling, was not reset. The sooner proper out-of-control recovery procedures were applied, the faster the simulator recovered. Flying mechanics were also crucial in not re-entering a spin when trying to recover (i.e. increasing angle of attack during recovery beyond that which caused the spin would cause the simulator to re-enter the spin) (Tabs AA-13 to AA-16).

7. WEATHER

All operations were conducted within their prescribed operational weather limitations. Neither the forecasted weather nor the observed weather were causal or contributory to the mishap.

a. Forecast Weather

The Mission Execution Forecast (MEF) for 21 March 2011 was valid from 1200Z to 2400Z. In-flight visibility was unrestricted, with unrestricted ceilings throughout the flight route. Additionally, the cloud forecast indicated scattered layers below 10,000 ft and isolated thunderstorms along the flight route from flight level (FL) 300 and below. Forecasted winds were unremarkable, varying from a North-West direction at approximately 10 knots at ground level, up to 55 knots at FL 300 (Tabs F-3 to F-5). The overall forecast weather along the flight route was within reasonable parameters for mission execution.

b. Observed Weather

The actual weather observations at the time of the mishap were scattered clouds estimated at 4,000 to 6,000 ft (Tabs F-3 and R-43). The observed weather was as forecasted and was not a factor in the mishap.

c. Space Environment

There was no evidence that any adverse conditions in the space environment affected the MA or its communications.

8. CREW QUALIFICATIONS

a. Training and Qualification

The MC was fully qualified to operate the F-15E Strike Eagle and was current and qualified to perform the mission (Tabs G-54, G-5, G-8 to G-13, G-14 to G-19, V-3.3, and V-4.3). This was the first combat sortie for the MW (Tabs G-15, G-17, and V-4.6). Training and qualification were not factors in the mishap.

b. Experience in the F-15E Strike Eagle

To be considered an experienced crew member in the F-15 "E" model, the member must have attained greater than 500 hours in a specific aircrew position. The MC was current on all egress and survival training. Neither member noted any deficiencies with the training they received. As summarized below, aircrew experience (or lack thereof) was not a factor in the mishap.

(1) Mishap Pilot

At the time of the mishap, the MP, an experienced F-15E pilot, was current and qualified to perform the mission (Tabs G-12 and G-13). The MP was certified "Combat Mission Ready" and was qualified to lead a four-ship formation (Tab G-4). The MP had performed his last mission checkride 6 April 2010 and was rated "Qualified, With Minor Discrepancies;" the discrepancies were debriefed and required no further action (Tabs G-12, T-5, and T-6). The MP flew his last instrument qualification checkride on 24 February 2011 and was rated "Qualified, No Discrepancies (Tabs T-3 and T-4)."

As of 22 March 2011, the MP had logged 1,469.4 primary hours in the F-15E, of which 661.1 hours were flown as a pilot and 808.3 hours were flown as a weapons system officer (WSO). The last sortie the MP flew before the mishap was on 19 March 2011 – two days prior to the mishap (Tab G-10). The sorties and hours flown by the MP 90 days prior to the mishap are as follows:

	Hours	Sorties
Last 30 Days	7.3	4
Last 60 Days	20.0	10

Last 90 Days	24.0	14
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As of 21 March 2011, the MP had flown a total of 1,516.0 flying hours in the following airframes: T-37 Tweet, T-38C Talon, and F-15E Strike Eagle. The MP was an experienced combat veteran with a total of 544.0 hours combat time – 295.1 hours as pilot and 248.9 hours as WSO. The MP completed emergency egress training on 22 April 2010 and Aircrew Flight Equipment familiarization training on 6 December 2010 (Tabs G-8 to G-11).

(2) Mishap Weapons System Officer

At the time of the mishap, the MW had not attained greater than 500 hours in his position and, therefore, was not considered an experienced F-15E WSO. The MW, however, had been certified “Combat Mission Ready” and was current and qualified to perform the assigned mission (Tabs G-5, and G-18 to G-19). As of 22 March 2011, the MW had logged 167.7 primary hours in the F-15E as a WSO (Tabs G-14 to G-17). The MW flew his last sortie on 19 March 2011 – two days prior to the mishap (Tab G-16). The sorties and hours flown by the MW 90 days prior to the mishap are as follows:

	Hours	Sorties
Last 30 Days	11.8	8
Last 60 Days	23.5	16
Last 90 Days	37.9	22

As of 21 March 2011, the MW had flown a total of 185.0 flying hours in two airframes, the T-38C Talon and the F-15E Strike Eagle. The MW completed emergency egress training on 30 July 2010 and Aircrew Flight Equipment familiarization training on 29 March 2010. The MW was combat mission ready but had had no combat time experience (Tabs G-14 to G-17, and V-4.3). The MW’s lack of experience was not a factor in the mishap.

9. MEDICAL

a. Qualifications

At the time of the mishap, all members of the MC were medically qualified to perform their crew duties and to participate in Operation ODYSSEY DAWN (Tabs V-3.6, V-4.12, V-4.13, and AA-23). There is no evidence to suggest medical qualifications were a factor in the mishap.

b. Health Prior to Mishap

Evidence suggests that at the time of the mishap the MC was in good health and had no medical issues that could have impaired their ability to perform flight duties or to carry out their assigned mission (Tabs V-3.6, V-4.12, V-4.13, and AA-23).

c. Post-Mishap Injuries

The MC sustained minor bruises, sprains, and strains consistent with emergency egress (ejection) and parachute landing from a high-performance aircraft. Specifically, the MP sustained strains

and bruising of the back, neck, and extremities. The MW also suffered a left knee and left ankle sprain. All symptoms were treated and resolved shortly after the mishap. Further review of the MC's medical status was unremarkable (Tabs P-5, and X-3). There were no other post-mishap health issues or injuries attributed to this mishap.

d. Toxicology

Due to the time lapse in personnel recovery, the MC was not directed to submit blood and/or urine samples after the mishap (Tabs V-2.14, V-4.11, and AA-23). However, blood and urine samples were collected from maintenance personnel involved in performing maintenance on the MA. Review of the maintenance members' toxicology reports did not reveal anything remarkable (Tab AA-25). There is no evidence to suggest that substance abuse was a factor in the mishap.

e. Lifestyle

Witness statements and review of aircrew and maintenance personnel medical records did not reveal significant or unusual habits, behaviors, or stressors that could have contributed to the mishap (Tabs V-3.6, V-4.12, V-4.13, and AA-23). There is no evidence to suggest lifestyle factors caused or contributed to this mishap.

f. Adequacy of Rest and Duty Periods

(1) Aircrew—Rest and Flight Duty Periods

Crew rest and crew duty time are described in AFI 11-202, Volume 3, Chapter 9, *General Flight Rules*, dated 22 October 2010. Specifically, in paragraph 9.4.5, "crew rest period" is defined as a period normally a minimum of twelve hours during a non-duty period before the flight duty period (FDP) begins. Activities acceptable during crew rest include eating, transportation, and rest. "Rest" is defined as a condition that allows an individual the opportunity to sleep (Tabs BB-4 and BB-5). Paragraph 9.8 of the same AFI states that aircrew require at least ten continuous hours of restful activities, including an opportunity for at least eight hours of uninterrupted sleep during the twelve hours immediately prior to the FDP. The AFI defines FDP as a period that begins when an aircrew member reports for a mission, briefing, or other official duty and ends when engines are shut down at the end of the mission, mission leg, or a series of missions. According to Table 9.1, the maximum FDP for a dual control fighter with basic aircrew is twelve hours (Tabs BB-4 and BB-5).

Evidence suggests that the MC received adequate crew rest prior to their 21 March 2011 mission. The mission, however, involved a shift in circadian pattern (shifting from a dayshift schedule to a nightshift schedule), which would normally lead to some fatigue symptoms. In addition, the mission involved a night combat sortie with a mid-day show-time for the aircrew. Aircrew described the operations tempo as high, as expected and trained for, with adequate crew rest given prior to flying operations. It is unlikely the MC experienced fatigue, slight or otherwise, this early into their 21 March 2011 mission (Tabs R-4, R-8, V-3.5, and V-4.12). Crew rest or crew duty time requirements were not violated nor were these factors causal or contributory to this mishap.

(2) Maintenance Personnel—Rest Periods and Duty Shifts

Duty shifts and rest periods for maintenance personnel are described in AFI 21-101, *Aircraft and Equipment Maintenance Management*, dated 26 July 2010. Specifically, paragraph 1.14.3 defines “rest period” as a block of time that gives a person the opportunity for at least eight hours of uninterrupted sleep in a 24-hour period. According to paragraph 1.14.7 of the same AFI, maintenance personnel must be afforded adequate rest periods and breaks. Normal shift of 12 hours may be exceeded to a maximum of 16 hours with authority of the Group commander or equivalent (Tabs BB-8 and BB-9). AFI 21-101 also defines duty time as the time that personnel report for duty to the time when their supervisor releases them. According to paragraph 1.14.4, personnel should not be scheduled for more than twelve hours of continuous duty time and must be provided a rest period after each shift. Time spent in contingency deployment processing lines and in-transit counts toward the total duty day, and may impact time available to perform maintenance at the destination (Tabs BB-8 and BB-9).

Based on the evidence, the duty schedules and rest periods afforded to maintenance and ground personnel during Operation ODYSSEY DAWN were unusual and fragmented, mainly consisting of two to three hours of sleep after performing 12 hour shifts in the first 48 hours of the operation (Tabs R-59, R-67, R-75, R-83 to R-84, V-5.13, V-5.14, V-6.10, V-6.11, V-7.8, V-8.6, and V-9.3.10). Although this fragmented and somewhat deficient rest was instrumental in the miscellaneous maintenance and documentation errors that occurred prior to the mishap; there was no clear evidence linking maintenance rest deficiency to the mishap sequence or outcome. Maintenance personnel duty schedules and rest periods were not factors in the mishap.

10. OPERATIONS AND SUPERVISION

a. Operations

At the time of the mishap, 492 EFS had a high combat operations tempo for a fighter squadron. All witnesses described the operations tempo as high, as expected and trained for. All witnesses described that the operations tempo did not negatively affect their ability to perform the mission (Tabs V-1.3, V-2.4, V-3.3, and V-4.3). Operations tempo was not a factor in the mishap.

b. Supervision

Operations supervision at 492 EFS was in accordance with governing directives (Tabs V-1.3, V-2.4, V-3.3, and V-4.3). Flight plans were properly filed and flight authorization was reviewed and approved as required (Tabs K-3 and K-4). The Operational Risk Management (ORM) is a tool to identify and mitigate risks at the lowest level. ORM assessment was completed by taking into account all crew member’s experience levels and was deemed acceptable (Tabs V-1.8, V-2.7, V-2.14, V-4.7). Supervision was not a factor in the mishap.

11. HUMAN FACTORS ANALYSIS

The board evaluated human factors relevant to the mishap using the analysis and classification system model established by the Department of Defense (DoD) Human Factors Analysis and Classification System (HFACS) guide, implemented by Air Force Pamphlet (AFPAM) 91-211, *USAF Guide to Aviation Safety Investigations*, dated 23 July 2001 (interim change dated 4 November 2008) (Tabs BB-11 to BB-44). Potentially relevant human factors to this mishap were identified and are discussed below.

a. General Definitions

Human factors analysis, as implemented by DoD-HFACS, identifies human errors that may have been the actual cause or factors contributing to a mishap event. Human factors are causal in nature if they directly cause the occurrence or directly contribute to the unwanted result. Under those conditions, the human factor is the driving force behind the unwanted result; and without it, the mishap event would not have occurred. Human factors could also contribute to an unwanted event. Human factors are contributory when other factors caused the unwanted result, but human factors add to the result either in occurrence or significance (Tabs BB-11 to BB-14).

b. Applicable Human Factors

Sufficient evidence suggests that the human factors discussed below were contributory to the mishap to various degrees. The actions of the MC during the mishap sequence were analyzed primarily from witness testimony and radio communication from the cockpit digital video recording. The MC followed the necessary procedures and performed their duties and responsibilities in accordance with their training and checklists in effect at the time of the incident (Tabs T-3 to T-6, T-7, T-8, and AA-3). However, several human factors played a role in the mishap. Specifically, there were skill-based and judgment-based errors, condition of individuals, supervision, and organizational human factors that affected the actions and performance of the MC and were contributory to the mishap.

(1) Organizational Processes: Procedural Guidance/Publications

Procedural guidance and publications are factors in a mishap when the published direction, checklists, graphic depictions, tables, charts or other written guidance is inadequate, misleading or inappropriate, and as a result creates an unsafe situation (Tabs AA-7 to AA-11, BB-21, BB-22, and BB-44). Recent improvements in the mission capabilities of the F-15E effectively expanded the flight envelope of the aircraft. However, procedural guidance and publications failed to evolve with aircraft capabilities. At the time of the incident, the Dash 1 did not use air-to-ground stores or representative weights during flight testing to determine the F-15E's limitations above 25,000 ft MSL (Tabs AA-9 and AA-14).

A safety supplement to the Dash 1 was published on 8 July 2011 addressing changes to out of control recovery checklist procedures and lateral asymmetry hazards, calculations, and flight

characteristics (Tab AA-11). The supplement, however, does not clarify, address, or update any prohibited maneuvers nor does it address the effects of lateral asymmetry changes during weapons employment. At the time of the mishap, Air Force technical procedures inadequately addressed the effect of lateral imbalance and aircraft controllability (Tabs AA-7 to AA-11, and AA-14 to AA-16). As a result, inadequate procedural guidance and publications were a contributing factor to this mishap.

(2) Organizational Climate: Perceptions of Equipment

Perceptions of equipment is a factor when over or under confidence in an aircraft, vehicle, device, system or any other equipment creates an unsafe situation (Tabs BB-21, BB-22, and BB-43). Evidence suggests that the MC was overconfident in the maneuvering capabilities of the F-15E. According to aircrew statements, at the time of the mishap, lateral imbalance was not treated as a matter of concern as long as aircraft maneuvers were conducted at an AOA less than 30 CPU. However, simulator analysis revealed an asymmetrically loaded F-15E flying at high altitude is prone to depart controlled flight and enter an unrecoverable spin during maneuvers that are at an AOA significantly less than 30 CPU (Tabs AA-7 to AA-11, and AA-14 to AA-16). Due to lack of available data concerning the F-15E's limitations when asymmetrically loaded, the MC had misleading perceptions of the capabilities of the aircraft they were flying, which added on to the unsafe situation that ultimately resulted in the mishap (Tabs R-38, R-44, R-53, V-1.14, V-2.11, and V-4.15). Perceptions of equipment, therefore, were a contributing factor in the mishap.

(3) Skill-Based and Judgment-Based Errors: Overcontrol/Undercontrol and Necessary Action—Rushed

It can be reasonably inferred from the available evidence, that the MP overcontrolled the aircraft while maneuvering away from the target area after weapons release. Overcontrol/Undercontrol is a factor when an individual responds inappropriately to conditions by either over controlling or under controlling the aircraft/system (Tabs BB-16, BB-17, and BB-24). The MP's overcontrol could have been the result of preconditions or temporary failure of coordination and was compounded by other human factors, such as rushing to complete a necessary action, channelized attention, and cognitive task oversaturation (Tabs R-4 and R-8). Overcontrol of the MA was a contributing factor in the mishap.

Also contributing to the mishap was the rush to complete the target objective and to maneuver away from the target location. During its approach to the designated target location, the MA had advanced approximately two miles ahead of the MFLA. It can be reasonably inferred that due to their forward position, the MC experienced a time crunch causing them to rush through the weapons release sequence. Time was also a concern as the MP, while avoiding potential threats, maneuvered the aircraft away from the target area. Rushed necessary actions are factors when the individual takes the necessary actions as dictated by the situation but performs these actions too quickly thus leading to an unsafe situation (Tabs R-4, R-8, BB-16, BB-17, and BB-25).

(4) Condition of Individuals: Channelized Attention and Cognitive Task Oversaturation

Channelized attention and cognitive task oversaturation are cognitive factors that affect an individual's perception or performance and result in human error or an unsafe situation. Both of these factors may have contributed to the mishap (Tabs BB-18 and BB-19).

The MC was in a combat environment which inherently requires multitasking and quick decision making. For example, while the MW was focusing on completing the necessary Bomb Damage Assessment (BDA) after the target strike, the MP was concentrating on maneuvering away from the target area. It is not uncommon in combat situations for the aircrew to become channelized in their actions. 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 higher or more immediate priority, leading to an unsafe situation (Tabs BB-18 and BB-28). In this case, the evidence suggests that the MC was channelizing its attention on the target engagement and egress from the target area. This channelized attention limited the MC from detecting the effects of high AOA on the MA and signs of impending departure from controlled flight (Tabs R-4, R-8, and R-50).

Combat situations, even when trained for, are prone to unexpected and unforeseen circumstances. When the MC was forced to troubleshoot and correct the fuel feed malfunction from the right external auxiliary tank, it added to their cognitive workload. This is evident from the fact that soon after, the MC found themselves two miles ahead in the formation. Due to their forward position, they were once again facing time compression to complete the assigned target objective. All of these events culminated into cognitive task oversaturation. 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 (Tabs R-39, R-40, R-48, R-54, BB-19, and BB-29).

(5) Supervisory Violations: Currency

Currency is a factor when supervision/leadership inappropriately allows an individual, who has not met the general training requirements for his job and is considered "non-current," to perform the mission element for which the individual is non-current (Tabs BB-21 and BB-41). Currency was not a factor as related to the flight crew. However, both ACES-II recovery parachutes were inspected and repacked by personnel who were overdue on recertification training (Tabs H-4, and H-10 to H-16). This specific discrepancy relating to currency of personnel was not contributory to the mishap.

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Operations Directives and Publications

- (1) AFI 11-2F-15E, Volume 1, *F-15E Aircrew Training*, dated 9 January 2007, certified current, 22 February 2010

- (2) AFI 11-2F-15E, Volume 3, *F-15E Operations Procedures*, dated 11 August 2009
- (3) RAF Lakenheath Instruction 11-2F-15E, Volume 3, *Local Operating Procedures*, dated 26 March 2009
- (4) AFI 11-202, Volume 1, *Aircrew Training*, dated 22 November 2010
- (5) AFI 11-202, Volume 2, *Aircrew Standardization/Evaluation Program*, dated 13 September 2010
- (6) AFI 11-202, Volume 3, *General Flight Rules*, dated 22 October 2010, USAFE, RAF Lakenheath Supplement, dated 23 May 2008
- (7) AFI 11-214, *Air Operations Rules and Procedures*, dated 22 December 2005, incorporating through change 2, dated 2 June 2009
- (8) AFI 11-418, *Operations Supervision*, dated 21 October 2005, incorporating through change 1, dated 20 March 2007, and administrative changes, dated 11 April 2011
- (9) TO 1F-15E-1-2-1, *Flight Manual*, dated 1 July 2009, incorporating Interim Safety Supplement (ISS)-2, Interim Operations Supplement (IOS)-1, IOS-3, and IOS-4
- (10) TO 1F-15E-1-2-1SS-5, ISS, dated 8 July 2011
- (10) TO 1F-15E-1-2-1CL-1, *Flight Crew Checklist*, dated 1 July 2009
- (11) AFTTP 3-1.F15E, *Tactical Employment*, dated 1 September 2010
- (12) AFTTP 3-3.F15E, *Combat Aircraft Fundamentals*, dated 1 September 2010

b. Maintenance Directives and Publications

- (1) AFI 21-101, *Aircraft and Equipment Maintenance Management*, dated 26 July 2010
- (2) TO 00-20-1, *Technical Manual Aerospace Equipment Maintenance Inspection, Documentation, Policies, and Procedures*, dated 1 September 2006
- (3) TO 00-5-1, *Air Force Technical Order System*, dated 1 May 2011
- (4) TO 1F-15E-2-22FI-00-1, *Auto-Flight System Fault Isolation*, dated 1 April 1991, Incorporating change 21, dated 1 March 2006
- (5) TO 1F-15E-2-22GS-00-1, *Automatic Flight System General System*, dated 15 January 1992, incorporating change 13, dated 1 March 2006
- (6) TO 1F-15E-2-DV-22-10-09, *Automatic Flight Control System (AFCS) Maintenance Built in Test (M-Bit)*, dated 15 July 1988, incorporating Change 27, dated 1 March 2006
- (7) TO 1F-15E-2-DV-22-10-30, *Removal and Replacement Flight Control Computer (FCC)*, dated 15 July 1988, incorporating Change 27, dated 1 March 2006
- (5) TO 1F-15E-2-DV-22FI-00-1, *Automatic Flight Control System Fault Isolation Manual*, dated 1 April 1991, incorporating change 21, dated 1 March 2006.

c. Known Deviations from Directives or Publications

There is no evidence indicating any deviations from directives or publications other than those previously noted.

13. ADDITIONAL AREAS OF CONCERN

In order to ensure effective aircraft maintenance, it is important that maintenance personnel are fully debriefed on aircraft malfunctions. While en-route to Aviano AB, IT, the MA's

malfunction identifiers from the previous two sorties, specifically its AFCS BIT codes, were not recorded in the maintenance IMDS system due to unavailability of LAN connectivity at the deployed location. The IMDS is an internet based maintenance data collection system. AFCS BIT codes would have assisted in isolating any detected flight control faults. It is critical for maintenance to receive all diagnostic information to properly troubleshoot issues. Although in this case maintenance personnel did not have IMDS access, the unavailability of historic AFCS BIT data for the aircraft was not a factor to the mishap.

//signed//

26 October 2011

SCOTT D. SHAPIRO, Colonel, USAF
President, Accident Investigation Board

UNITED STATES AIR FORCE AIRCRAFT ACCIDENT INVESTIGATION BOARD

STATEMENT OF OPINION

F-15E STRIKE EAGLE, T/N 91-00304
NEAR BENGHAZI, LIBYA
21 MARCH 2011

Under 10 U.S.C. 2254(d), any opinion of the accident investigators as to the cause of, or the factors contributing to, the accident set forth in the accident investigation report 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 21 March 2011, at approximately 2129 hours Zulu, an F-15E Strike Eagle, tail number 91-000304, operated by 492d Expeditionary Fighter Squadron based out of Aviano Air Base, Italy departed controlled flight and entered into an unrecoverable spin during a night combat mission in support of Operation ODYSSEY DAWN. The mishap aircraft (MA) was destroyed on ground impact in an unpopulated area near Benghazi, Libya. The mishap crew (MC), consisting of the mishap pilot (MP) and the mishap weapons system officer (MW), ejected safely with minor injuries and was recovered by friendly forces. Financial loss of the MA and associated equipment totaled \$48,190,996.50. There were no known civilian injuries or damage to other property.

I found by clear and convincing evidence that the cause of the mishap was the MA's sudden departure from controlled flight during a combat egress maneuver when the mishap pilot (MP) momentarily exceeded aircraft controllability performance parameters. There was sufficient evidence to determine that one or a combination of the following factors substantially contributed to the mishap: (1) ambiguous F-15E technical order guidance concerning maneuvering limitations with aircraft lateral asymmetry while configured with external stores; (2) unknown or misunderstood combat loaded F-15E aircraft performance while operating at or above 30,000 feet (ft) mean sea level (MSL); and (3) unpublished, therefore, unfamiliar dynamic lateral directional stability as a function of external stores asymmetry caused by weapons release.

2. DISCUSSION OF OPINION

I have developed my opinion on the causes of this mishap and its contributing factors through careful consideration of witness testimony, assistance by technical advisors, simulator testing/recreation, and review of supporting documentation to include aircraft maintenance records, personnel training records, technical guides, and Department of Defense and Air Force instructions. This evidence demonstrated that weather conditions, aircrew qualifications, flight and organizational supervision, operations tempo, maintenance status and preflight checklist

inspections associated with the accident were not causal or contributory to the mishap. Since the MA was destroyed on impact and the impact site was located in a combat zone, no aircraft systems and components could be retrieved for technical analysis and exact recreation of mishap flight and aircraft parameters. Therefore, I focused my investigation and analysis on witness testimony, thorough review of published guidance, and simulator evaluation of maneuvering limitations associated with the MA's lateral asymmetry and flight altitude.

a. Misunderstood Aircraft Lateral Asymmetry Limitations

The mishap was caused during a combat egress maneuver when the MP momentarily exceeded aircraft controllability performance parameters resulting in the MA's sudden departure from controlled flight and entered an unrecoverable spin.

Since there was no physical evidence, the AIB used an F-15E Mission Training Center (MTC) simulator to examine flight characteristics of the Strike Eagle under conditions similar to those experienced by the MA. The AIB found the F-15E simulator has a varying stability limit measured in angle of attack (AOA) for varying lateral asymmetry. To clarify, as lateral asymmetry increases, the stability limit (Critical AOA) decreases. The AIB replicated the MA's configurations and flight conditions to examine aircraft performance. Allowing for variances in altitude, AOA, and lateral asymmetry, the AIB examined 128 simulator scenarios at least three times each. Evaluation of the simulator scenarios confirmed that the Strike Eagle is more susceptible to departure at higher altitudes, angles of attack, and lateral asymmetries. The simulator departed controlled flight as low as 26 CPUs. The Flight Manual (Dash 1) states the F-15E is fully controllable up to 30 CPUs with lateral asymmetry and does not limit maneuverability above 30 CPUs until 5,000 foot pounds (ft-lb) lateral asymmetry or when carrying air-to-ground stores. Also, the simulator departed unexpectedly at times when slowing through Mach 0.82 and less than 30 CPUs. The Board did not attempt to define these limits but rather to identify aircraft departure susceptibility at less than 30 CPUs.

The AIB also evaluated the F-15E's spin recovery with lateral asymmetry. Recovery was not always possible on the higher limits of lateral asymmetry and was severely degraded, if not impossible, when the Control Augmentation System (CAS) was not reset. The sooner proper out-of-control recovery procedures were applied, the faster the simulator recovered. Flying mechanics were also crucial in not re-entering a spin when trying to recover (i.e. increasing angle of attack during recovery beyond that which caused the spin would cause the simulator to re-enter the spin). Therefore, I find significant evidence from simulator evaluation that misapplied or ambiguous F-15E technical order guidance concerning maneuvering limitations with aircraft lateral asymmetry while configured with external stores could have caused the aircraft to depart controlled flight.

b. Unknown or Misunderstood Combat Loaded F-15E Performance

The MA was operating above 30,000 ft. There is limited performance data for the F-15E's maneuverability above 30,000 ft and no lateral asymmetry performance data for greater than 10,000 ft-lb imbalance. The Dash 1 does not contain guidance for lateral-directional stability with a greater than 10,000 ft-lb lateral imbalance. The Dash 1 and the Combat Employment

Fundamentals Manual (AFTTP 3-3.F-15E) do not address maneuverability above 25,000 ft. It is my opinion that the Dash 1 capabilities and limitations sections have not evolved with the F-15E capabilities envelope expansion. The F-15E combat loaded performance while operating at or above 30,000 ft MSL is not known.

c. Lateral Asymmetry Awareness

I find significant evidence that a lateral imbalance caused the aircraft to depart controlled flight once the Critical AOA was breached. The Dash 1 fails to fully explain lateral-directional control with an operationally configured aircraft. There is no Dash 1 explanation for each external store's contribution to lateral-directional stability. This would have given the MC a clearer understanding of stability as stores were released and would have guided them if stores should be jettisoned for lateral-directional stability. Also, the mishap aircraft's operational flight program (Suite 6E) has a known deficiency for stores release on the right conformal fuel tank stations. Specifically, aircrew step-over function is inhibited on the right conformal fuel tank stations. The aircrew cannot step-over degraded or failed stores to release a good munition later in the aircraft's sequence of release. This malfunction is tracked as USAF Suite 6E PR 53538 in Boeing ClearQuest database, entered on 17 November 2009 and deferred for fix until USAF Suite 7E. This anomaly caused a modification to the 48 FW standard conventional load and caused the aircraft to be loaded with a lateral imbalance of 8,168 ft-lbs at takeoff. Releasing a left munition further increased the imbalance to 11,275 ft-lbs. This could have been further exacerbated by the mishap aircraft's potential fuel imbalance. Aircrew need to clearly understand the effects of dynamic lateral asymmetry to safely and effectively employ the F-15E in combat. Such understanding did not exist.

3. CONCLUSION

I found by clear and convincing evidence that the cause of the mishap was the MA's sudden departure from controlled flight because it exceeded Critical AOA during a combat maneuver. This resulted in the aircraft's total loss amounting to \$48,190,996.50. There was sufficient evidence that other factors may have contributed to the mishap.

//signed//

26 October 2011

SCOTT D. SHAPIRO, Colonel, USAF
President, Accident Investigation Board