

UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION
BOARD REPORT



F-15C, T/N 80-0041
NELLIS AFB, NV



LOCATION: NELLIS AFB, NV
DATE OF ACCIDENT: 24 OCTOBER 2011
BOARD PRESIDENT: LT COL DYLAN WELLS
Conducted IAW AFI 51-503, Aerospace Accident Investigations



DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR COMBAT COMMAND
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FEB 10 2012

MEMORANDUM FOR ACC/JA

**SUBJECT: Accident Investigation Board Report F-15C, T/N 80-0041, 24 Oct 11,
Nellis AFB, NV**

I have reviewed the Accident Investigation Board Report regarding the F-15C, T/N 80-0041, 24 Oct 11, Nellis AFB, NV. The report prepared by Lieutenant Colonel Dylan T. Wells complies with the requirements of AFI 51-503 and is approved.


WILLIAM J. REW
Lieutenant General, USAF
Vice Commander

Attachment:
Accident Investigation Board Report

EXECUTIVE SUMMARY

AIRCRAFT ACCIDENT INVESTIGATION BOARD

F-15C, T/N 80-0041 ACCIDENT NELLIS AFB, NEVADA 24 OCTOBER 2011

On 24 October 2011 at 1602 local time, an F-15C aircraft, tail number (T/N) 80-0041, departed controlled flight during a single-ship Advanced Handling Characteristics (AHC) sortie on the Nevada Test and Training Range (NTTR). The mishap aircraft (MA) initiated a left-hand spin at 19,000 feet mean sea level (MSL) after the mishap pilot (MP) attempted a break turn followed by a level heading reversal. The MP attempted to regain control of the MA by following the Spin Recovery Display commands. After multiple revolutions and losing several thousand feet of altitude without any noticeable change in spin characteristics, the MP lowered the landing gear in an attempt to aid MA recovery. At an MP-estimated 8-9,000 feet MSL (terrain elevation is 4,200 feet), the MA recovered from its spin. The MA settled into a 50-70 degrees nose low attitude indicative of an attempt to regain flying airspeed. The MP selected afterburner on both engines attempting to initiate a dive recovery from the MA's low energy state. As aft control stick was applied and the MA neared the horizon, the MA nose sliced to the left. In this slice, the MP went from a controlled situation to an uncontrolled ejection situation that necessitated immediate ejection. The MA crashed into an uninhabited area of the NTTR owned by the Bureau of Land Management (BLM). The MP ejected without serious injury, the MA was destroyed, and no NTTR or BLM structures were damaged.

Given the limited evidence available, the AIB President was unable to determine a mishap cause by clear and convincing evidence. He did however find six contributing factors tied to four key segments of the mishap sequence. The contributing factors were links, which if broken, would have precluded aircraft loss. The first three of these six contributing factors aided the initial departure and included: aircraft structural imperfections (specifically the radome), inadequate focus on AHC topics (most notably effects of MA fuel weight and configuration on performance), and improper application of flight controls based on those characteristics. Next a misperception of operational conditions either contributed to the MP's inability to prevent the departure from progressing into a spin or from realizing aggressive MA maneuvering with its mishap sequence characteristics could flow directly to a spin with little warning. Additionally, an inability to attain/maintain full control authority during the lower-rate spin that ensued precluded MA spin recovery prior to required ejection altitudes. Likewise, the AHC maneuvers chosen (all performed at normal operating regimes) exposed the MP to non-optimal spin recovery altitudes despite any mission risk assessment that occurred. Ultimately, lowering landing gear aided spin recovery and increased control authority. It imposed other restrictions. Aft control stick, lower airspeed, lower altitude, higher dive angle and unusual gear down dive configuration created a situation where the aircraft did not have the energy or responsiveness to perform the requested maneuver. The MA's nose sliced to the left forcing immediate MP ejection. Since this nose-slice occurred below the uncontrolled ejection altitude, it was not deemed contributory to the mishap.

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

COMMONLY USED ACRONYMS & ABBREVIATIONS

%MAC Percentage Mean Aerodynamic Chord	KEAS Knots Equivalent Airspeed
AB Afterburner	KIAS Knots Indicated Airspeed
AC Aerodynamic Center	LA Legal Advisor
ACC Air Combat Command	LASDT Low-Altitude Step-Down Training
ACES II Advanced Concept Ejection Seat II	MA Mishap Aircraft
ACT Air Combat Tactics	MAC Mean Aerodynamic Chord
ADO Assistant Director of Operations	MAJCOM Major Command
AF Air Force	MDM Medical Member
AFB Air Force Base	MFC Main Fuel Control
AFI Air Force Instruction	MFR Memorandum For Record
AFMES Armed Forces Medical Examiner System	Mil Military Power
AFTO Air Force Technical Order	MP Mishap Pilot
AFTTP Air Force Tactics Techniques and Procedures	MPCD Multi-Purpose Color Display
AGL Above Ground Level	MSL Mean Sea Level
AGRS Aggressor Squadron	MXG Maintenance Group
AHC Advanced Handling Characteristics	MXM Maintenance Member
AIB Accident Investigation Board	NOTAMS Notice to Airmen
AMAD Airframe Mounted Accessory Drive	NACTS Nellis Air Combat Training System
AMU Aircraft Maintenance Unit	NAFBI Nellis Air Force Base Instruction
AMXS Aircraft Maintenance Squadron	ND Nose Down
AOA Angle of Attack	NTTR Nevada Test and Training Range
APG Airframe and Powerplant General	NU Nose Up
ARI Aileron Rudder Interconnect	NV Nevada
AFTO Air Force Technical Order	OFP Operational Flight Program
ASP Avionics Status Panel	ORM Operational Risk Management
BFM Basic Fighter Maneuver	Ops Operations
BLM Bureau of Land Management	OSC On Scene Commander
BP Board President	PDM Post Depot Maintenance
CAS Control Augmentation System	PFL Planned Flight Lead
CATM Captive Air Training Missiles	PRD Pilot Reported Discrepancy
CC Central Computer	PM Pilot Member
CDC Career Development Course	PRCA Pitch Roll Channel Assembly
CG Center of Gravity	PTC Pitch Trim Compensator
CPU Cockpit Units	PTM Practice Training Missile
CIVV Compressor Inlet Variable Vanes	R/T Receiver/Transmitter
DEEC Digital Electronic Engine Control	RAF Royal Air Force
DO Director of Operations	RCCV Rear Compressor Variable Vane
EDU Engine Diagnostic Unit	REC Recorder
ELT Emergency Locator Transmitter	RESCAP Rescue Combat Air Patrol
EOR End of Runway	RPM Revolutions per Minute
EP Emergency Procedure	RTB Return to Base
FDL Fighter Data Link	SAR Search and Rescue
FDP Flight Duty Period	SEFE Standardization Evaluation Flight Examiner
FL Flight Lead	SIB Safety Investigation Board
FOD Foreign Object Debris	SII Special Interest Item
G Gravitational Load Factor	SM Statute Mile
G-Ex G Awareness Exercise	SME Subject Matter Expert
HPO Hourly Post Flight	SOF Supervisor of Flying
HUD Heads-Up Display	SPO Systems Program Office
HZ Hertz	SRD Spin Recovery Display
IAW In Accordance With	Stab Stabilator
IMDS Integrated Maintenance Data System	Stab-Ex Stability Exercise
IP Instructor Pilot	TACAN Tactical Air Navigation

TCTO Time Compliance Technical Order
TEG Test and Evaluation Group
TES Test and Evaluation Squadron
T/N Tail Number
T.O. Technical Order
USAF United States Air Force

USAFWC United States Air Force Warfare Center
U.S.C. United States Code
Vol. Volume
WG Wing
Z Zulu Time

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

SUMMARY OF FACTS

1. AUTHORITY AND PURPOSE

a. Authority

On 15 November 2011, Major General Roger A. Binder, Vice Commander, Air Combat Command (ACC), appointed Lieutenant Colonel Dylan T. Wells as the Accident Investigation Board (AIB) President to investigate the 24 October 2011 crash of an F-15C, Tail Number (T/N) 80-0041, 85 miles north of Nellis Air Force Base (AFB). An AIB was conducted at Nellis AFB, NV, from 2 December 2011 to 30 December 2011, pursuant to Air Force Instruction (AFI) 51-503, *Aerospace Accident Investigations*. A Legal Advisor (LA), Maintenance Member (MXM), Medical Member (MDM), Pilot Member (PM), and Recorder (REC) were appointed. (Tabs S-3, Y-3, Y-5)

b. Purpose

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

2. ACCIDENT SUMMARY

On 24 October 2011, an F-15C piloted by the Mishap Pilot (MP) of the 422nd Test and Evaluation Squadron (422 TES), ACC, Nellis AFB, NV, experienced a departure from controlled flight that resulted in a spin. The spin occurred during the last planned maneuvers of a single-ship Aircraft Handling Characteristics (AHC) sortie on the Nevada Test and Training Range (NTTR). (Tabs N-9, S-3, V-1.10 to 1.11, V-1.23) The MP was able to recover from the spin by approximately 4,000-5,000 feet above ground level (AGL); however, the spin left the aircraft in a nose-low attitude, requiring an aggressive recovery to avoid ground impact. As the MP pulled aft on the control stick, a nose slice to the left occurred. (Tabs S-16, Image 214; V-1.26) After the nose slice occurred, the MP successfully ejected around 1,400 feet AGL. (Tab H-8) The Mishap Aircraft (MA) crashed approximately 10 miles north-northwest of Alamo Landing Field, NV, 20 miles to the west-southwest of Caliente Flight Strip, NV and 85 miles to the north-northwest of Nellis AFB, NV. (Tab S-3) The MA impact was on an unoccupied portion of Bureau of Land Management (BLM) land in rural Lincoln County, NV, destroying the \$32 million aircraft. (Tabs P-3, S-3) There were no casualties or civilian injuries.

3. BACKGROUND

The MP was a member of the 422 TES. (Tab G-3) The 422 TES is a squadron within the 53rd Test and Evaluation Group (53 TEG); both are based at Nellis AFB. The 53 TEG is a part of the 53rd Wing (53 WG), the latter is headquartered at Eglin AFB. (Tab LL-3 to 9, 13) The MA, by agreement, was maintained by the 57th Aircraft Maintenance Squadron (57 AMXS), which is in turn a part of the 57th Maintenance Group (57 MXG). (Tab LL-27)

a. 53rd Wing



The 53 WG, located at Eglin AFB, FL, serves as the focal point for the Combat Air Forces in electronic warfare, armament and avionics, chemical defense, reconnaissance, and aircrew training devices. The wing is responsible for operational testing and evaluation of new equipment and systems proposed for use by these forces. Current wing initiatives include advanced self-protection systems for combat aircraft, aircrew life support systems, aerial reconnaissance improvements, new armament and weapons delivery systems, and improved maintenance equipment and logistics support. The 53 WG, comprised of four groups, numbers more than 2,000 military and civilians at 20 various locations throughout the U.S. The wing reports to the U.S. Air Force Warfare Center (USAFWC) at Nellis AFB and is a direct reporting unit to ACC. (Tab LL-3)

b. 57th Wing



The 57 WG is the largest composite wing in the U.S. Air Force (USAF). It provides advanced aerospace training to world-wide combat air forces and showcases aerospace power to the world while overseeing the dynamic and challenging flying operations at Nellis AFB. The 57 WG conducts advanced aircrew, space, logistics and command and control training through the USAF Weapons Instructor Course (WIC), "RED FLAG" and "GREEN FLAG" exercises. Important components of the training include adversary tactics replication (provided by the wing's aggressor squadrons) and graduate level instruction and tactics development (accomplished through each of its schools). The wing additionally supports the USAFWC's test and evaluation activities and showcases US air power through the USAF Air Demonstration Squadron. The wing is comprised of seven distinct organizations: the 57th Adversary Tactics Group, 57th Maintenance Group, 57th Operations Group, WIC, USAF Advance Maintenance and Munitions Officers School, USAF Air Demonstration Squadron, and 561st Joint Training Squadron. (Tab LL-17 to 20)

c. 422 TES



The 422 TES is responsible for the execution of fighter operational test at Nellis AFB. Members of the squadron carry out operational test and evaluation and tactics development and evaluation projects assigned by ACC. The 422 TES is composed of aircrew and support personnel sustaining five divisions of fighter aircraft: A-10C, F-15C, F-15E, F-16C, and F-22A. The 422 TES conducts operational tests for ACC on new hardware and software upgrades to each of the five aircraft in a simulated combat environment. The 422 TES also develops and publishes new tactics for these aircraft. The results of these tests directly benefit aircrews in ACC, Pacific Air Forces, and U.S. Air Forces in Europe by providing them with operationally proven hardware and software systems. Current tests include Helmet Mounted Integrated Targeting system testing for the A-10C, ground maneuvering target destruction for the F-16C, a \$1.9B Radar Modernization Program for the F-15E, new avionics software updates for the F-15C, and

implementing the first-ever air-to-ground radar mapping capability for the F-22A. Also, the squadron provides core pilots to the F-35 program and will eventually carry out operational test for the Air Force's newest fighter aircraft. (Tab LL-15)

d. F-15 Eagle

The F-15 Eagle is an all-weather, extremely maneuverable, tactical fighter designed to permit the AF to gain and maintain air supremacy over the battlefield. Eagle pilots utilize the aircraft's maneuverability and acceleration, range, weapons, and avionics to achieve desired effects in aerial combat. The F-15C has electronic systems and weaponry to detect, acquire, track, and attack enemy aircraft while operating in friendly or enemy-controlled airspace. The weapons and flight control systems are designed so one person can safely and effectively employ the jet in air-to-air combat. The F-15C model entered the USAF inventory in 1979. (Tab LL-21 to 26)

4. SEQUENCE OF EVENTS

a. Mission

EAGLE flight, a two-ship formation of F-15C aircraft, planned to fly a test profile of recent software and hardware advances involving the Air Combat Tactics (ACT) mission set against six adversaries from the 64th and 65th Aggressor Squadrons (64 AGRS and 65 AGRS). This ACT mission was further focused on short-range detection, maneuvering, and two-ship engagement with these adversaries, and was part of a comprehensive test plan for the new avionics suite. (Tab V-1.6 to 1.7) EAGLE 01 was planned to be flown by the planned flight lead (PFL), who was a current and qualified F-15C instructor pilot (IP). The original EAGLE 02 was planned to be flown by the MP, who was a current and qualified F-15 IP as well. (Tab K-6) The mission was authorized by the 422 TES Operations Supervisor (also referred to as Top-3), who is in charge of daily operations in accordance with (IAW) AFI 11-401. (Tab K-5)

b. Planning

Mission planning began the Friday prior on 21 October 2011 and was completed prior to the coordination brief on 24 October 2011. (Tab V-1.7) All mission planning items were uneventful. The coordination briefing with the adversaries started on time and took 15 minutes. Then the PFL and MP took a 10 minute break and followed with their element brief. The element brief lasted 45 minutes and covered their planned test intercept mission flow. (Tab R-29) The PFL discussed administrative items, tactical portion and alternate mission. (Tab V-1.9) However, the specific maneuvers for the alternate mission were not discussed. (Tab R-31) The brief concluded 15 minutes before "step" time. (Tab R-29) "Step" refers to the time the pilot will depart the squadron to allow time for sufficient preflight of the aircraft and follow-on ground operations. In between the brief and the step, maintenance and operations personnel arrived at the conclusion that only one of the two EAGLE aircraft would be available. (Tab R-29) The PFL and MP came to an agreement for the MP to fly an alternate AHC mission. (Tabs R-29, V-1.10) Since the assigned Operations Supervisor was unavailable, the PFL (who was a qualified Operations Supervisor) acted in that role for step. (Tabs T-4, V-10.5) The PFL, as the acting Operations Supervisor, and MP developed a new plan to share the

airspace with the adversaries who would also perform an alternate mission. (Tab V-1.9) Since an alternate card was not required, the MP elected to use the products generated for the flight rather than developing new products. (Tab V-1.11) The MP filed himself as EAGLE 01, a single-ship mission, for the AHC sortie. The MP did not fill out a new ORM sheet. (Tab K-8) All required items were completed during the step brief. (Tab V-1.11 to 1.12) The MA flew earlier that day, but nothing other than minor flyable discrepancies were noted on the previous flight. (Tab D-15)

c. Preflight

The MP arrived at the aircraft about 50 minutes prior to takeoff and performed a normal preflight. (Tab V-1.9, V-5.5 to 5.6) The MP noticed nothing abnormal in the aircraft forms. The MP performed a walk-around/preflight and noted no abnormalities to flight control services, fuel systems, radome, or the expected configuration. (Tab V-1.15) The MP climbed into the aircraft and noticed no abnormal cockpit switch positions, had no abnormal indications during start, and noticed no abnormal ground, fuel, or flight control checks. (Tab V-1.17) All EAGLE taxi and end of runway (EOR) checks were uneventful. (Tab V-1.19) The MP did not remember the Fighter Data Link (FDL) procedures for the day. (Tab V-1.21) Further analysis shows the MP did not enable the Video Tape Recorder System (VTRS) and no usable data could be retrieved from the Nellis Air Combat Training System (NACTS). (Tab II-3)

d. Flight

On time takeoff, departure, and entry into the NTTR, specifically Coyote Bravo airspace, were uneventful. (Tabs N-4 to 8, V-1.20) Upon arriving in the NTTR, the MP completed several routine flight checks, to include an ops check. (Tab V-1.20 to 1.22) Ops checks are accomplished on departure and periodically during maneuvers so that the pilot has the most up-to-date situational awareness of aircraft fuel and oxygen state as well as cabin pressurization.

Upon completion of his required airspace entry checks, the MP proceeded to fly a low-altitude step-down training (LASDT) profile below 5,000 feet AGL within the airspace. This portion of the mission was uneventful. Once the MP's external wing tanks were empty, he climbed above 5,000 feet AGL to proceed with the AHC portion of his mission. (Tab V-1.22) The MP performed his usual technique of reprogramming the angle of attack (AOA) warning tone to 0 (which turns the tone off) once the external tanks were empty. (Tab V-1.18) AOA is the angle between the relative wind direction and the aircraft's wings.

The MP's plan was to climb back up to 19,000 feet mean sea level (MSL) in order to begin flying the AHC portion of the mission. (Tabs V-1.22 to 1.24) According to the MP, he performed AHC maneuvers within the full range of the F-15C capabilities; this included high speed, high G maneuvers to low speed, high AOA maneuvers using the full range of power settings available. The MP flew all of these maneuvers in a clockwise flow (right-hand turns) and noted nothing unusual during these maneuvers. (Tab V-1.22 to 1.24)

Between these various AHC maneuvers, the pilot would conduct ops checks in between setups, ensuring that the fuel was feeding and that internal wing tanks were balanced. Every time the MP

performed these ops checks, he verified that the wing tanks were empty. The MP noted nothing abnormal with regards to the fuel system. (Tab V-1.23)

At approximately 1602 local time (based on analysis of Blackjack's radar track), the MP started his last maneuver leading up to the mishap sequence. (Tabs M-3, JJ-18) Blackjack is the scheduling agency for real-time NTTR airspace use and it functions as a range monitoring and advisory control system located at Nellis AFB. The MP's last ops check yielded nothing abnormal, with a recollected fuel state of 5,300 pounds, all of the internal tanks feeding, and internal wing tanks balanced. The MP's intent was to practice one last AHC maneuver, a level reversal, before returning to Nellis AFB. (Tab V-1.24)

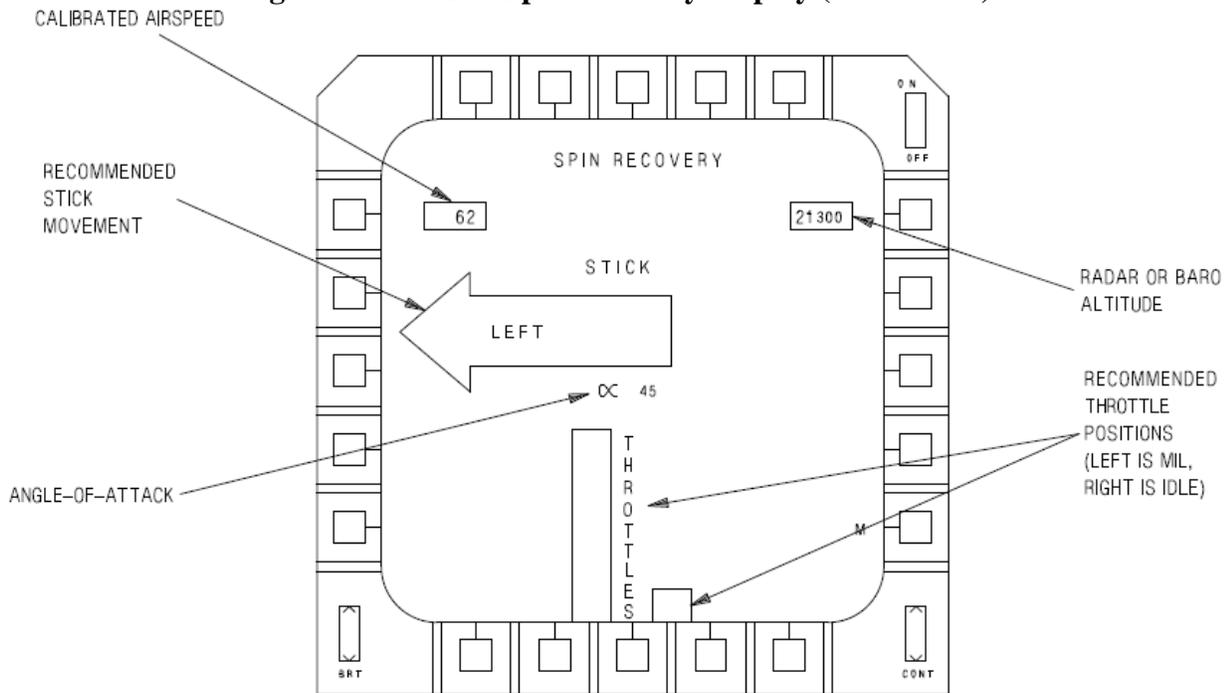
The level reversal is an aggressive defensive basic fighter maneuver (BFM) designed to cause an offensive enemy aircraft to overshoot the defender's flight path or to cause misaligned fuselages, denying the adversary the ability to employ ordnance. (Tab AA-72) The initial maneuver is an aggressive defensive break turn (a maneuver used to change direction as quickly as possible) with around 90 degrees of bank angle and throttles at idle. This initial turn may be held based on the adversary's follow-on maneuver, and the subsequent follow-on turn will be a quick unloaded (defined by decreased G and AOA on the jet) roll in the opposite direction to another aggressive idle power turn. These aggressive turns will bleed off the aircraft's energy. With the power setting also at idle, it is common for the jet to enter and be sustained in the high AOA and low airspeed regime. (Tab AA-64)

According to the MP, the initial parameters of the level reversal were 19,000 feet MSL, 375 knots indicated airspeed (KIAS), and in a right-hand turn. The MP selected idle power and rolled right with lateral stick input set to approximately 80 degrees of bank. The MP remembers performing an aggressive break turn to the right, registering over 8 Gs on the MA's heads up display (HUD). (Tab V-1.25) The MP held the stick aft, continuing this turn for around 3-4 seconds before executing his reversal back to the left. (Tab V-1.28) This reversal was executed at between 250 to 300 KIAS. (Tab V-1.25) The MP stated he kept his feet on the rudder pedals, and that only stick input was used. (Tab V-1.28) The MP executed an aggressive unload, placing the stick to a perceived neutral position before rolling left with lateral stick input to set his bank angle to 60-70 degrees. (Tab V-1.29) As he applied longitudinal pressure aft on the stick, the MA's nose, which was initially above the horizon, yawed left and sliced abruptly below the horizon as the MP started to hear the departure warning tone. (Tab V-1.30) A departure from controlled flight is characterized by a large, uncommanded flight path change. (Tab AA-12) Additionally, the flight manual, T.O. 1F-15A-1, describes this tone as a warning indicator of departure or potential impending departure. (Tab AA-35) This beeping tone sounds when the yaw rate reaches 30 degrees per second. As the yaw rate increases, the beep rate increases, reaching a maximum beep rate at 60 degrees per second yaw rate. (Tab AA-7)

The MP recalls freezing the stick halfway or three-quarters from the full aft position when he heard the departure warning tone, with his feet still neutral on the rudder pedals. (Tab V-1.29) Immediately thereafter, as soon as the MA's nose sliced left, the MP states he neutralized his controls while keeping the throttle setting still at idle. (Tab V-1.26) The MA continued to depart controlled flight with the yaw rate increasing rapidly. (Tab V-1.26 to 1.27) The MP saw the Spin Recovery Display (SRD) appear on his Multi-Purpose Color Display (MPCD) and that the yaw rate warning tone had

stabilized to what he perceived as the maximum beep rate. (Tab V-1.33) See Figure 1 for a representative SRD.

Figure 1. F-15C/D Spin Recovery Display (Tab AA-11)



Neutralizing the controls following the nose slice did not recover the MA. The MA settled into a spin at a 20-30 degrees nose low attitude, relatively level with little to no oscillations. (Tab V-1.25) According to the MP, he felt “a slight amount of G-forces, kind of ninety degrees out from the back of the seat, so pushing you forward in the seat a little bit. ... I didn’t feel like I had to do a push-up off of the glare shield or anything like that though.” (Tab V-1.25 to 1.26) The MP, after neutralizing his controls, applied full left lateral stick into the direction of the spin. (Tab V-1.26) The MP had to move his feet off the rudder pedals due to his left leg preventing him from achieving full left stick deflection. (Tab V-1.31) The MP then applied differential power by splitting the throttles against the spin, placing the left throttle into full military (sub-AB) power and the right throttle at idle. (Tab V-1.26) The MP perceived no changes in the yaw rate warning tone and did not feel the jet recovering. Passing what the MP perceived as 13,000 feet MSL, the MP lowered the landing gear, which is consistent with the out of control recovery checklist. (Tab V-1.34 to 1.35) This gear-down configuration is also confirmed by photographs from eyewitnesses near the mishap location. (Tab S-15)

Figure 2. MA Dive Recovery (Tab S-15)



After lowering the gear, the MA came out of the spin while passing 9,000 feet MSL. (Tab V-1.26) The MP neutralized the controls and selected maximum afterburner on both throttles. Based on the MP's memory of events and eyewitness photographs, the MA was around 50 degrees nose low when it started its recovery from the spin. (Tabs V-1.35, S-15) The MP attempted a slow application of aft stick pressure to fly the jet out from the dive, but realized he was at a very low altitude condition and was "starting to get that ground rush." (Tab V-1.33) Photographs taken near the mishap site show the MA's nose about 5 degrees above the horizon with an engine exhaust trail visible. (Tab S-15 to 16) Following this maneuver, the aircraft sliced aggressively to the left. As the MA passed below 7,000 feet MSL, the MP began his ejection sequence. Based on the eyewitness photographs, the pilot initiated his ejection sequence with the MA at around a 70-80 degrees nose low attitude, in a left bank. (Tabs V-1.36, S-16 to 17) Additionally, based on analysis of these photos, it was estimated that the ejection altitude was approximately 1,404 feet AGL or 5,586 feet MSL and the speed was approximately 122 KIAS. (Tab H-8) The MA impacted the ground a few seconds after the MP's ejection. The MP survived the ejection with very minor injuries. (Tab X-3)

Figure 3. MP Ejection (Tab S-17)



e. Impact

The MA impacted unoccupied BLM land approximately 10 miles north-northwest of Alamo, NV, at approximately 1603 local time. The coordinates of the impact site were N37 28 30.24 W115 15 53.79. (Tab S-3) Based on orientation of the crash site and witness photos, the MA heading was southeast and in a nose-low attitude at the time of impact. (Tab S-4, 17) The debris field covered a relatively small area with most of the wreckage found within a 100 yard radius of the center. (Tab S-5) On 4 December 2011, the AIB team found a 34-inch long portion of the right missile rail over half a mile north-northeast of the impact site. (Tab Z-3) There were no off-road vehicle tracks or apparent impact craters immediately by the rail. Two mishap responders were interviewed, and neither could explain how the wing rail ended up in the location where it was discovered by the AIB. They did state that if transported by ATV, the rail would have been in a non-enclosed box. (Tab V-8.6, 9.5) Unfortunately, no log was kept as to individual item transportation. (V-8.4) The missile rail appeared charred, indicating that it was likely on the aircraft at impact and not likely contributory to the mishap. (Tab Z-5) There were no civilian casualties or civilian property damage, and only minor environmental clean-up costs. (Tab P-5)

Figure 4. Eyewitness Photo of MA Impact (Tab S-19)



Figure 5. MA Crash Site (Tab S-10)

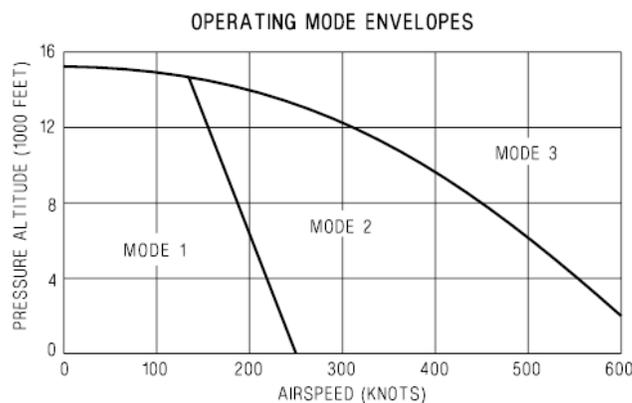


F-15C, T/N 80-0041, 24 October 2011

f. Egress and Aircrew Flight Equipment

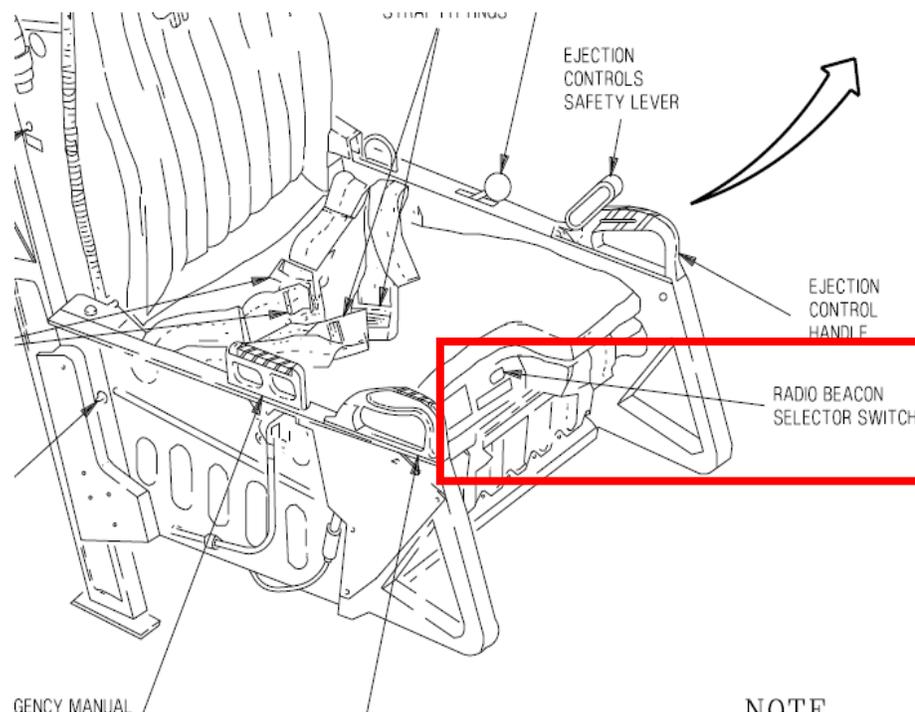
The pilot initiated successful ejection within the performance envelope of the Advanced Concept Ejection Seat II (ACES II) ejection system. A Mode 2 ejection resulted, despite the MA being within the altitude and airspeed parameters for a Mode 1 ejection. A Mode 1 ejection should occur at airspeeds less than 250 knots equivalent airspeed (KEAS) and altitudes below 15,000 feet MSL. The mishap sequence never put the MA in a Mode 2 regime, as seen in Figure 6. The primary difference is that in a Mode 2 ejection, a seat drogue parachute is deployed, and the deployment of the aircrew parachute is slightly delayed. If a Mode 2 sequence is initiated in the Mode 1 regime (as in this case), there is increased risk that the aircrew parachute may not deploy completely due to the delay, increasing the likelihood of injury. In this mishap, however, the MP's aircrew parachute deployed fully and he sustained no serious injuries. (Tab H-3 to 9) Further investigation showed two other environmental sensors from the same lot number were locked in Mode 2 selection. (Tab I-12)

Figure 6. Ejection Modes (Tab AA-79)



The MP's emergency locator transmitter (ELT) beacon did not alert any local aircraft or radar stations via the aircraft emergency frequency (Guard). (Tabs JJ-21, R-11) The MP testified that he did not recall what setting his Radio Beacon Selector switch was set to during ground operations. (Tab V-1.16, 1.40) Access to the Radio Beacon Selector switch is gained through a cutout in the front of the seatpan. The switch is a rocker switch with two settings, MAN and AUTO. With MAN selected, the radio beacon will not activate at man-seat separation. With AUTO selected (standard setting during training sorties), the radio beacon activates at man-seat separation. (Tab AA-77) The MP was able to contact other airborne aircraft with his survival radio and coordinate with Search and Rescue personnel. (Tabs R-11, V-1.40)

Figure 7. Ejection Seat (Tab AA-45)



All required life support and survival equipment inspections were current. (Tab EE-3 to 11) The MP was wearing the appropriate life support equipment for a daytime AHC mission. (Tab EE-13 to 15) Neither egress nor aircrew flight equipment were causal or contributing factors in this mishap.

g. Search and Rescue

At 1610 local time on 24 October 2011, the Lincoln County Sherriff's Office received report of a possible aircraft crash and contacted the Nellis AFB Command Post. (Tab N-9, 20, 23) Following the successful ejection, the MP started walking toward the nearby highway to help expedite his rescue. Aircraft that were already flying in the area, including F-15C, F-16, and A-10 aircraft, were vectored to perform a Rescue Combat Air Patrol (RESCAP) over the area. (Tabs N-20, R-10, R-19) REDHAWK 1, an F-15C, was the initial on-scene commander (OSC). The MP was able to communicate with the airborne RESCAP via hand-held radio, and reported that he was ambulatory and had only minor injuries. (Tab V-1.40) The OSC was able to visually locate the MP, worked with the MP to determine an appropriate pickup location, and passed that location to recovery forces. OSC duties were then transferred from REDHAWK 1 to BOAR 1, a Nellis A-10, until rescue operations were complete. A helicopter was dispatched to pick up the MP, and the MP signaled the helicopter using smoke and flare. (Tab V-1.41) The MP was transported via the helicopter to the Mike O'Callaghan Federal Hospital on Nellis AFB for evaluation. (Tab V-1.41)

h. Recovery of Remains

Not applicable.

i. Simulator Analysis of Mishap Engagement.

Simulator testing was conducted in the Boeing Simulator Facility, St. Louis, MO on 12 and 13 December 2011 with Boeing subject matter experts (SME). Parameters for testing were derived from the interview with the MP on 5 December 2011 and non-privileged data obtained from Part 1 of the SIB report. The simulator modeling assumed entry parameters IAW the MP interview. After the SRD appeared, spin recovery controls were applied IAW the display (Figure 1) and with a two to five second reaction time factor.

Multiple scenarios were flown simulating variations due to aircraft center of gravity (CG), pilot flight control inputs, mechanical failures of flight control surfaces, and radome imperfections, modeling their effects on departure susceptibility, spin entry, and aircraft spin characteristics. (Tab GG-3 to 11) This process allowed a large number of possibilities to be examined, with a combination of these variables most likely contributing to the mishap:

Variable 1: Introduction of radome imperfection that made the MA susceptible to departures at very high AOAs.

- T.O. 1F-15A-1 pg. 6-9 states, “imperfections in the forward 8-10 inches of the radome such as bent/misaligned nose caps or cuts/blisters in the rain erosion boot can cause strong yawing tendencies (i.e. nose slices) at very high AOA’s.” (Tab AA-36) Additionally, AFTTP 3-3.F-15C pg. 4-18 states:

Normally, even without imperfections, the airflow around the radome begins to separate at very high AOA levels (i.e., typically 65 to 70 CPU [cockpit units]). The separation occurs unevenly causing a slight yaw due to the pressure differential... A 27-foot moment arm from the CG to the nose multiplies this small yawing force, making it significant enough to overcome inherent lateral-directional stability. Typically, pilots do not reach these AOA levels, nor could they sustain them long enough to depart. But, with imperfections in the radome accelerating this separation, pilots can see significant yaw rates at AOA levels as low as 50 CPU. (Tab AA-69)

- **Note:** The F-15C does not display AOA directly. Instead, it displays AOA as CPU on a scale of 0 through 45. AOA is displayed on a gauge in the cockpit and in the HUD. (Tab AA-57) The aircraft can attain AOA in excess of the maximum displayed 45 CPU. When this occurs, 45 CPU will be displayed on the gauge and in the HUD until AOA decreases below 45 CPU. (Tabs AA-40, KK-11) CPUs are roughly equivalent to actual AOA plus 10 degrees. (Tab AA-29)
- Interviews with the MP, the pilot prior to the mishap sortie, and maintenance personnel did not indicate any radome issues prior to the flight. (Tab V-1.17, V-3.3, V-5, V-6.4) However, a Boeing White Paper from June 2005 indicated a radome looked fine under visual inspection, yet “detailed laser survey of the outer surfaces revealed irregularities beyond allowable production specs, but difficult to see or feel.” (Tab KK-7 to 23)

- Simulations verified that an aircraft with a radome imperfection would be the most susceptible to a departure at high AOA conditions. It was very difficult to spin the aircraft in the simulator without the radome imperfection. In these cases, either flight control system failures and/or extreme misapplication of controls needed to occur to spin the jet. (Tabs GG-8 to 9, HH-29 to 31)

Variable 2: Increasing longitudinal instability based on fuel state and center of gravity (CG) location.

- Longitudinal stability is a function of the static margin. Static margin is the distance between the aircraft's aerodynamic center (AC) and CG. (Tab AA-68) The F-15 always maintains a positive static margin (aircraft CG forward of AC), making it inherently stable and departure resistant. (Tabs AA-40 to 41, KK-4 to 5) However, the static margin decreases during normal flight operations based on the CG shifting aft as the F-15 burns fuel. (Tab AA-4) The MA's fuel weight was around 5,300 pounds with the internal wing tanks balanced and feeding. (Tab V-1.23, 1.28) This is a light fuel weight for the F-15C.

Variable 3: Misapplication of controls.

- At the start of the mishap sequence the MA was at a fuel state that allowed it to achieve faster pitch rates, higher peak AOA, and higher sustained AOA. (Tab GG-13 to 16) Abrupt or aggressive longitudinal application of the stick, with decreased throttle settings, may have allowed the MA to achieve AOAs higher than aircraft can report. According to the MP, he performed an aggressive pull at 19,000 feet MSL with a starting airspeed of 375 KIAS. Based on his recollection, the MP achieved over 8 Gs on the initial pull, and he held the stick in that aft position for 3-4 seconds. (Tab V-1.25, 1.28) Performing this maneuver in the simulator, it was possible to achieve 8 Gs with an abrupt pull aft. Additionally, with the power settings at idle, the aircraft would decrease to an airspeed of 250 to 300 KIAS when holding the stick aft for 3-4 seconds.
- In the simulator, the reversal to the left was performed aggressively based on the MP testimony. According to T.O. 1F-15A-1 pg. 6-11, "[i]f the pilot moves the stick forward more rapidly than AOA response can occur, full aileron authority can be restored before the aircraft returns to lower AOA, with the resulting greater probability of departure." (Tab AA-38) However, aggressive reversal to the left with stick at longitudinal neutral or forward of neutral never induced a departure in the simulator. Once the reversal to the left was accomplished, the aircraft would only depart with aggressive application of the stick aft. This is contrary to the MP testimony, since he stated that he froze the stick halfway to three-quarters from the full aft position, and then heard the departure warning tone. (Tab V-1.28)
- According to the T.O., aircraft recovery capability from a departure is based on how quickly the controls are neutralized. (Tab AA-38) According to McDonnell Douglas Aerospace's report from July 1997, serious radome imperfections coupled with an abrupt control input in a high AOA situation could result in an immediate nose slice that progresses into a departure,

even with immediate neutralization of controls. (Tab KK-63) In the simulator, barring any flight control malfunctions, an aircraft with the radome imperfection recovered when the controls were immediately neutralized (less than one second reaction) at the first indication of the departure warning tone. Any delays (greater than 1-2 seconds) with the neutralization of controls could progress the aircraft into a spin. This was dependent on the aircraft's bank angle and energy state. Based on numerous simulator runs, an increased bank angle at a higher energy state created a faster and sharper departure and subsequent entry into a spin. Energy state played a key role as to how long full aft stick had to be held in order to transition from a departure to a spin, with lower energy states requiring the pilot to hold the stick aft longer (greater than 3-5 seconds) in order to spin the jet. (Tab GG-8 to 9)

Variable 4: Aircraft control applications and their effects on the spin.

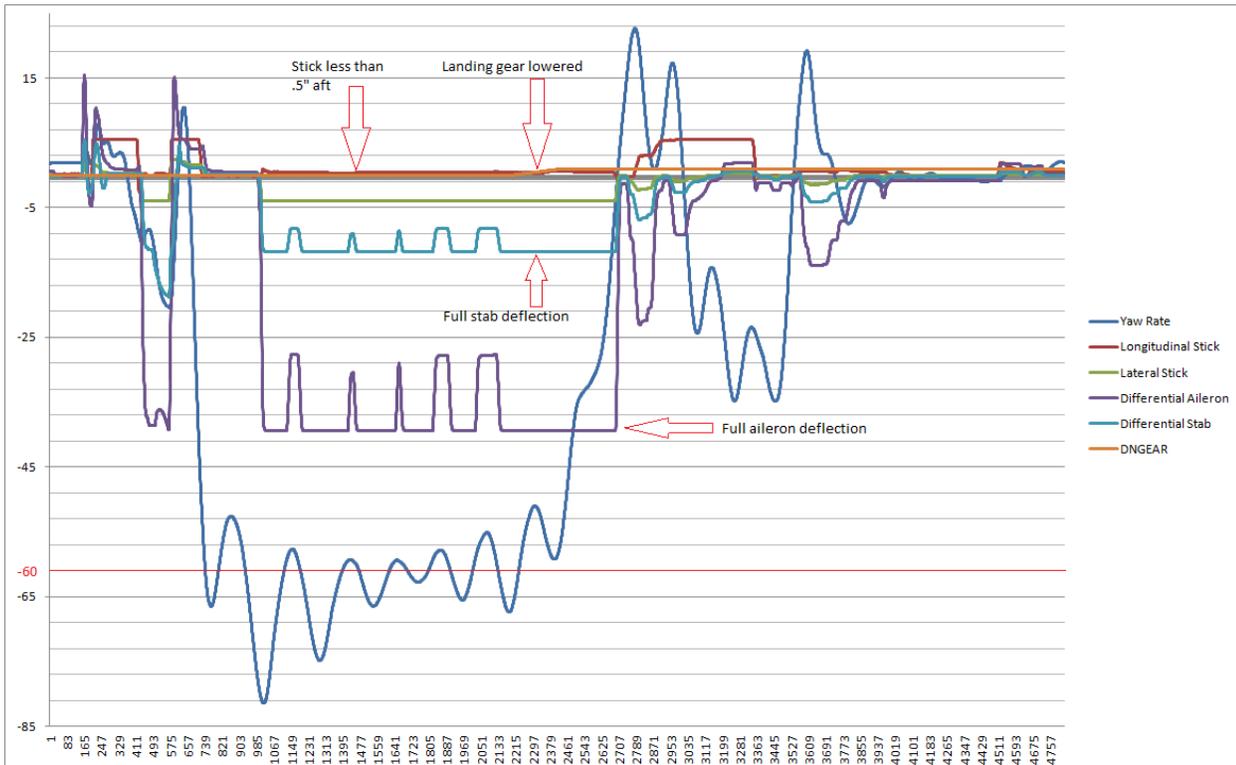
- Based on the MP's description of the sensations he experienced during the spin, the jet was at a yaw rate that was less than a classic definition of a flat erect spin but greater than a low rate erect spin. (Tabs AA-40 to 42, HH-3 to 26, V-1.26) This was confirmed in the simulator. For almost all of the runs, after the initial oscillations, the jet would consistently stabilize in a flat erect spin, with the nose 20 to 30 degrees below the horizon with a yaw rate varying between 50 to 75 degrees per second. (Tab GG-9)

- According to the T.O:

When the spin recovery mode is not operating (yaw rate below 60°/second), the longitudinal stick must be closely centered to insure large anti-spin aileron deflection when lateral stick is input. Positioning the longitudinal stick either forward or aft of neutral reduces the aileron deflection available for recovery. Obtaining neutral longitudinal stick may be extremely difficult due to forces encountered during a departure situation. Occasionally, the amplitude of the spin oscillations will reduce and the low-rate spin will become very smooth. Should this occur, aircraft recovery will be slowed. If the aircraft is in the low rate spin mode and is not recovering with full anti-spin controls, landing gear may be lowered. This results in a control system change, which insures full anti-spin aileron deflection is available with full lateral stick regardless of longitudinal stick position. Again, recovery from the spin may not be apparent for several turns after appropriate recovery controls are applied. (Tab AA-41)

- This issue was confirmed in the simulator and is shown in Figure 8.

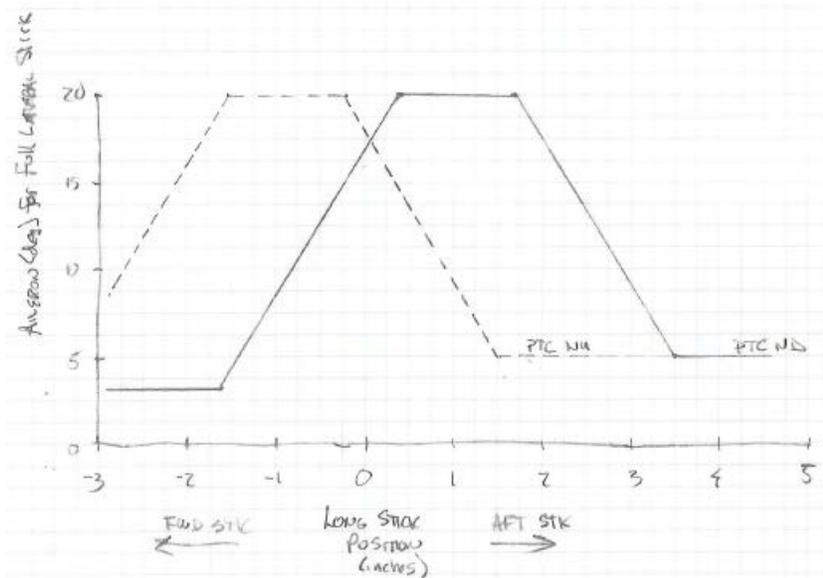
Figure 8. Plot of simulator run Day 1 Run 27 (Tab HH-7)



Note: X-axis is time (hundredths of a second), Y-axis reflects yaw rate (degrees per second), longitudinal stick placement (inches), stick placement (inches), degrees deflection.

- Despite a concerted effort by the simulator pilot to place the stick in an exact longitudinal neutral position, this was never achieved. According to the T.O., the ratio of aileron/differential stabilator deflection to lateral stick motion is adjusted automatically based on airspeed, longitudinal stick position, and gear position in order to prevent adverse yaw. (Tab AA-5) The system that controls that function is the Lateral Ratio Changer. Figure 9 show the schedule followed by the Lateral Ratio Changer.

Figure 9. Lateral Ratio Changer Schedule



Note: The X-axis is longitudinal stick position in inches; Y-axis is the aileron deflection in degrees; The dashed lines is the schedule with the PTC nose-up (NU), solid line is the schedule with the PTC nose-down (ND). (Graph and information provided by Boeing SME)

- Based on this figure, which assumes that the gear is up and that the full spin recovery logic is not enabled, the amount of aileron deflection provided is a function of the what the Pitch Trim Compensator (PTC) commands as well as the longitudinal stick position (in inches). The PTC provides the capability of automatically trimming the aircraft based on the desired stick force selected by the pilot. (Tab AA-28) Forward stick input causes the PTC to run towards its nose-down limit. Aft stick input causes the PTC to run to its nose-up limit. Even in a spin, the PTC is still fully functional and sees stick movement as a change in commanded G-level, and tries (unsuccessfully in a spin) to automatically trim the aircraft. Because of this, the PTC affects the Lateral Ratio Changer schedule which adjusts aileron deflection, affecting the pilot's ability to obtain full control authorities, regardless of stick position. (Tab GG-13)
- The MP testified that despite full left lateral stick input and differential throttles, he perceived no changes in the yaw rate warning tone or any sign that the jet was recovering. (Tab V-1.26) This could be due to unintentional aft input on the stick – a situation that was simulated and analyzed. This is also a natural tendency corroborated by discussions with F-15 test pilots, based on the forces experienced. In the simulator, being aft of longitudinal neutral as opposed to forward consistently produced longer or no recovery. (Tab GG-9)

Variable 5: Misapplication of controls during the unsuccessful dive recovery.

- Passing what the MP perceived as 13,000 feet MSL, the MP lowered the landing gear IAW the spin recovery procedures. (Tabs AA-14, V-1.26 to 1.31) This gear-down configuration is also confirmed by photographs from eyewitnesses near the mishap location (Tab S-16). Of note, according to T.O., as the aircraft's AOA increases between 35 and 40 CPU, the indicated

barometric altitude may become erroneous and can read as much as 1,500 feet higher than the aircraft's actual altitude. (Tab AA-32)

- After lowering the gear, the MA started to come out of the spin passing what he perceived as 8 to 9,000 feet MSL. (Tab V-1.35) The MP neutralized the controls and selected maximum afterburner on both throttles. Based on the MP's memory of events and eyewitness photographs, it was estimated that the aircraft was around 50-60 degrees nose low when it started its recovery from the spin. (Tabs V-1.35, S-16) The MP testified he applied aft stick input slowly, to fly the jet out from the dive, but realized he was at a very low altitude and perceived ground rush. (Tab V-1.33) Photographs taken near the mishap site show the MA nose about 5 degrees above the horizon with engine exhaust trailing the jet, indicating a power setting change. Following this maneuver, the MA slices aggressively to the left, also indicated by eyewitness photographs. (Tab S-17)
- When flying this portion of the mishap profile in the simulator, lowering the landing gear provided the aircraft with the full spin recovery logic necessary to recover. (Tabs AA-5, GG-11) The jet had full aileron and differential stabilator deflection when the aircraft was spinning at less than 60 degrees per second, regardless of longitudinal stick position. Normally during these cases, it required the jet about two to three revolutions and 2,000 to 4,000 feet of altitude to recover from the spin. (Tab GG-10 to 11)
- It should be noted that in the simulator, when lowering the gear at 13,000 to 12,500 feet MSL (based on the MP's interview), the jet would start to recover from a spin at around 8,000 to 9,000 feet MSL. The aircraft would establish itself in a 70 to 80 degrees nose low condition and if the throttle was immediately placed into AB and aft stick application was delayed until the airspeed was above 150 KIAS, with AOA kept at less than 30 CPU, it was possible to recover from the dive at around 5,000 to 6,000 feet MSL. The only times the jet would not recover were during any situations that involved flight control malfunctions or system failures. Applying aft stick pressure rapidly (less than 2 seconds) during recovery, with the airspeed below 150 KIAS, spiking the AOA above 30 CPU, and bringing the nose to the horizon, would prevent the jet from gaining sufficient recovery airspeed, regardless of how rapidly throttles were placed into afterburner during the recovery phase. (Tab GG-11)

5. MAINTENANCE

a. Forms Documentation

At the time of the mishap, the MA total aircraft time was 6,334.8 hours. The #1 engine (left engine), serial number (S/N) PW-E680801, had 9,600.1 hours total engine operating time with 1,024.4 operating cycles. The #2 engine (right engine), S/N PW-E711817, had 6,784.2 hours total engine operating time with 3,940.9 operating cycles. (Tab D-3) The #1 engine was a Pratt & Whitney F-100/220E engine and the #2 was a Pratt & Whitney F-100/220. (Tabs D-3, J-18 to 23)

A review of the current Air Force Technical Order (AFTO) 781 forms showed no discrepancies with engines, mechanical/hydraulic systems, or flight controls on the MA. A historical review of forms

back to July 6, 2011 revealed no major structural or electrical discrepancies. The Integrated Maintenance Data System (IMDS) was reviewed in conjunction with the historical forms to validate the maintenance actions. None of the open Time Compliance Technical Orders (TCTO) were grounding items. All TCTOs that were accomplished had been accomplished within proper technical guidance. TCTOs were not a contributing factor to the mishap. (Tab D-6 to 55)

The MA had flown a total of 57 times between 6 July and 24 October 2011; 30 of those flights were classified as Code I (no significant maintenance problems noted), 19 were Code II (aircraft has some degraded system performance, but is still flyable), and eight were Code III (significant problems that require repair before the aircraft can fly again). (Tab U-27 to 43) The MA's eight Code III discrepancies and the corrective actions taken, within 90 days of the mishap were:

Table 1. MA Code III Discrepancies Last 90-days (Tab U-27 to 44)

Date	Discrepancy	Corrective Action
8 July 2011	Radar Bit failure indicated: radar tactical performance was NOT code I.	The Operational Flight Program (OFP) was reloaded to fix the problem.
15 July 2011	ASP (Avionics Status Panel) 10 (Right Main Landing Gear) orange.	The right main landing gear actuator down limit switch was replaced
1 August 2011	Apparent Central Computer (CC) malfunction	The CC was replaced.
18 August 2011	Tactical Air Navigation (TACAN) was inoperative	Replaced the Fighter Data Link (FDL) Receiver/Transmitter (R/T)
18 August 2011	Canopy Unlocked warning light on	Corrected by rigging of the canopy position switch and lock position switch
23 August 2011	Right engine RPM gauge failure	The gauge was replaced
9 September 2011	ASP 18 orange	Engine troops troubleshot in accordance with applicable Technical Order (TO) and downloaded a 2000 Fault Code. They inspected the Digital Electronic Engine Control (DEEC) and its coolant lines with No Defect Noted. Completed an engine run with fault not returning and returned aircraft to service.
7 October 2011	Internal Navigation System aligned properly on ground but would not take inputs airborne.	Maintainers replaced the Navigation Control Indicator Panel and the Internal Navigation Unit.

None of the above listed Code III discrepancies were considered contributory to the mishap.

b. Inspections

(1) Mishap Aircraft

A phase inspection, also called an Hourly Post flight (HPO), is a scheduled, in-depth inspection of the aircraft. The phase inspection occurs every 400 flying hours. The last major inspection was the 400-hour HPO, which is a 7-day inspection, was accomplished on 9 November 2010. The aircraft had approximately 212.7 hours until its next major inspection, another 400-hour HPO. (Tabs D-19, D-29, U-47)

The Friday before the mishap, a preflight inspection was accomplished. A preflight inspection is used to verify the air worthiness of an aircraft before the next flying day. (Tab D-6) It is valid for up to 72 hours; aircraft flying on Monday morning will have a preflight accomplished on the Friday night prior to meet that time frame. The inspection was accomplished after the MA had been down for three days while undergoing an 18-month gun inspection. (Tab U-25) Items identified during the preflight were assessed to have no connection to the mishap. (Tab D-5 to 29)

On the day of the mishap, a thruflight inspection was accomplished after the first flight. (Tab D-6) A thruflight is used to inspect an aircraft in between flights to ensure it is safe and secure for another flight on that same day. The crew chief had to service the right main landing gear strut and had an evaluation performed on some loose rivets on the bottom of the #2 intake. (Tab D-17) The evaluation concluded that the rivets were flyable. (Tabs D-18, V-4.5) Even if the rivets came loose, they would be self-contained and could not enter into the engine. (Tab V-4.5)

(2) Mishap Engines

The MA #1 engine was last replaced on 4 October 2011 for two of the Compressor Inlet Variable Vanes (CIVV) being loose beyond limits. (Tab U-21) The CIVVs help to direct airflow entering the engines. Once the #1 engine was replaced, no further discrepancies were noted. The #2 engine was removed on 19 September 2011 to facilitate other maintenance (replacing two cracked flexible fairings which attach to the airframe above the augmentor section of the engine). No further discrepancies were noted on the #2 engine. (Tab U-21)

The last inspection for the #1 engine was a 1200-hour borescope inspection accomplished on 20 August 2011. (Tab D-3) This engine was replaced on 4 October 2011, as indicated above. The #2 engine had a 100-hour inspection on 26 August 2011. A borescope inspection is an internal inspection of the engine's turbine blades using a high powered flexible scope. Neither inspection identified any defects or discrepancies. (Tab U-23)

c. Maintenance Procedures

The last time the MA was down for an extended amount of time was the week prior to the mishap. The aircraft had a scheduled inspection due on the gun system. (Tab U-25) The 18-month gun inspection is an in-depth inspection of the gun and canister. The gun and canister are removed and sent to the armament shop, torn down for inspection and rebuilt. During this time, the crew chief of

the jet will work on any pending discrepancies while the jet is not flyable. There were no defects detected during this inspection that would have an impact on the MA's flight worthiness.

d. Maintenance Personnel and Supervision

A review of maintenance training records showed that all personnel who worked on the MA were fully qualified. All maintenance personnel that worked on the MA were appropriately experienced. (Tab U-45) There was no evidence that manning constraints or the tempo of flying operations played a role in the mishap.

e. Fuel, Hydraulic and Oil Inspection Analysis

Samples from the fuel, oil, and hydraulic carts used to service MA systems were all taken and sent for analysis. All findings were normal. (Tab D-57) Samples from the oil cart used to service the engine were within acceptable limits. (Tab U-3, 5, 15)

f. Unscheduled Maintenance

All documented unscheduled maintenance for the MA for past 90 days was reviewed. A historical review since last phase was also conducted. None of the identified discrepancies were pertinent to the mishap. (Tab U-27 to 43)

The 757 AMXS Eagle AMU performed all maintenance actions and properly documented them IAW applicable TOs.

6. AIRCRAFT AND AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS

a. Condition of Systems

Upon impact, the MA and most of its components were destroyed. All major pieces of the wreckage were collected, and several salvageable parts were sent off for testing. Multiple components were destroyed beyond testing capabilities.

b. Testing

(1) Engines

Although the #1 engine had severe impact damage, several of the main components were able to be removed to be tested. The DEEC and Engine Diagnostic Unit (EDU) work together as the brain and memory of the engine. The EDU for the #1 engine was destroyed in the crash, but the DEEC was recovered and sent to the manufacturer (Hamilton Standards) for analysis. Their analysis showed no recorded fault codes for the #1 engine. The Main Fuel Control (MFC) provides and controls the fuel scheduling for the engine. The MFC showed that the #1 engine was operating at a low power setting upon impact. The Rear Compressor Variable Vane (RCVV) actuator, the CIVV cylinder, and Bleed Strap were all analyzed and all showed the engine was placed at an idle power setting. (Tab J-19)

The #2 engine also had severe impact damage, but several of the main components were able to be removed and tested. The DEEC and EDU were sent to the manufacturer for analysis. The DEEC had an advisory fault code of 159 (which has no operational significance to the mishap). The MFC showed that the #2 engine was operating at a low power setting upon impact. The RCVV actuator, the CIVV cylinder, and Bleed Strap were all analyzed and all showed the engine was placed at an idle power setting. (Tab J-21)

(2) Flight Control Surface Actuators

The flight control actuators (rudders, stabilators, and ailerons) were sent to Boeing Failure Analysis lab for testing. (Tab J-11 to 42) All actuators were inspected prior to removal from wreckage and all were found installed properly. Not all of the components recovered from the wreckage could be sent for testing. The Pitch/Roll Channel Assembly (PRCA) and Aileron Rudder Interconnect (ARI) act as the brain of the flight control system. Both components were damaged beyond the scope of analysis. (Tab J-13)

Right Horizontal Stabilator Actuator

The right stabilator actuator was found intact in the aircraft upon impact. The stabilator actuator had no defects that would prevent hydraulic application. With hydraulic and electrical power applied, there were no evident signs of actuator chatter or leakage. (Tab J-12, 35) The actuator responded in very similar fashion to the left actuator, showing no unusual difference between them. (Tab J-35, 38 to 40)

Left Horizontal Stabilator Actuator

The left stabilator actuator was found intact in the aircraft upon impact. The stabilator actuator had no defects that would prevent hydraulic application. With hydraulic and electrical power applied, there were no evident signs of actuator chatter or leakage. (Tab J-12, 35) The actuator responded in very similar fashion to the right actuator, showing no unusual difference between them. (Tab J-35 to 38)

Left Aileron Actuator

The left aileron actuator had severe heat exposure damage and could not be pressurized at Boeing. The actuator was found in fully retracted (trailing edge up) position when received for testing. There were no pre-impact anomalies found on the left or right aileron actuators. (Tab J-12, 13, 36, 40, 41)

Right Aileron Actuator

The right aileron actuator had severe heat exposure and post impact damage could not be pressurized at Boeing for testing. The actuator was received in the extended position (trailing edge down). There were no pre-impact anomalies found on the left or right aileron actuators. (Tab J-12, 13, 36, 40 to 42)

Right Rudder Actuator

The right rudder actuator was not able to be pressurized at Boeing due to the amount of burn damage. The rotary output was found slightly trailing edge right when received. X-rays and partial teardown showed no impact anomalies. (Tab J-11, 35, 40)

Left Rudder Actuator

The right rudder actuator was not able to be pressurized at Boeing due to the amount of burn damage. The rotary output was found slightly trailing edge right when received. X-rays and partial teardown showed no impact anomalies. (Tab J-11, 35)

Left/Right Flap Actuator and Speedbrake

Both flap actuators and the speedbrake actuator were salvaged from the wreckage. They were found with damage from impact and subsequent fire. There was no evidence of actuator malfunction that contributed to the mishap.

(3) Radome

The radome is a key factor in the stability of the F-15 during flight. Even minor defects or damage to the radome could induce an excessive yawing motion in the aircraft. (Tab KK-7 to 23) A historical review of forms and IMDS showed the MA's radome was initially installed on 6 September 2006 at Robins AFB during depot inspection and again installed on 26 October 2007. There was no available documentation explaining why the radome was removed in 2007. (Tab U-19) There was also an evaluation done on 30 September 2010 which found the radome serviceable. (Tab U-17) The radome was destroyed upon impact to the extent that it was not possible to determine its condition at the time of the mishap.

(4) Flight Control Cables

There are eight cables in total on the F-15. There are two lateral and longitudinal, upper and lower cables on left side, and same for the right side. The cables connect the bellcranks from the front of the wing root to aft of the wing root. All flight control cables that were recovered were sent to Air Force Research Laboratory Failure Analysis at Wright-Patterson AFB, and no evidence of pre-existing damage was found. (Tab J-44 to 61)

(5) Rudder Breakout Assembly

The rudder breakout assembly was recovered post impact. The assembly was cracked and broken due to ground impact. There is no evidence of pre impact failure. (J-14)

7. WEATHER

a. Forecast Weather

Nellis AFB: At brief time, 1115 local time, weather for takeoff at Nellis AFB was forecast to be broken clouds at 12,000 feet, and overcast at 22,000 feet, with no significant weather. Visibility was forecast to be seven statute miles (SM). Winds were projected to be from the south at 12 knots. Surface temperature was forecast to be 82 degrees Fahrenheit. (Tab F-10)

Northern Ranges Operating Area: At brief time, 1115 local time, weather for the flying airspace was forecast to be scattered clouds at 25,000 feet and 40,000 feet, with no significant weather. Visibility was forecast to be 7 SM. Winds were projected to be from the southwest at 12 knots with gusts to 18 knots. (Tab F-10)

b. Observed Weather

Observed weather at the mishap location was clear skies, unrestricted visibility with winds from the south southeast at seven knots, temperature 80 degrees Fahrenheit. (Tab F-9)

c. Space Environment

Not applicable.

d. Operations

The mission was flown in compliance with weather requirements (AFI 11-202, Vol. 3, General Flight Rules, dated 22 October 2010, and AFI 11-214, Air Operations Rules and Procedures, dated 22 December 2005, incorporating through Change 2, dated 2 June 2009). Weather was not a factor in the conduct of the mission or the mishap.

8. CREW QUALIFICATIONS

The MP was a fully qualified instructor in F-15C and F-15D aircraft (F-15C/D). (Tab G-8) All necessary flight currencies were up-to-date and all required training for the planned mission was current IAW AFI 11-2F-15, Volume 1, Flying Operations, F-15 Aircrew Training, dated 7 September 2010. The MP performed his most recent instrument qualification in the F-15C/D on 8 July 2010. The MP's IP upgrade was accomplished on 1 May 2011 during his initial instructor mission qualification ride prior to his reassignment to Nellis AFB in July. (Tab G-4 to 5) The MP had a total of 791.5 hours of military flying time and of this total, the MP had 563.1 hours of primary F-15C/D time, with 22.8 hours as an F-15C/D Instructor Pilot (Tab G-8). The MP met all currency and training requirements prior to the mishap sortie, and was qualified for the mission. (Tab G-14 to 18, 21, 25 to 26)

At the time of the mishap, the MP's recent flight time was as follows:

F-15C, T/N 80-0041, 24 October 2011

Table 2. MP 30/60/90-Day Lookback (Tab G-9)

	30 DAY TOTAL SORTIES	30 DAY TOTAL HOURS	60 DAY TOTAL SORTIES	60 DAY TOTAL HOURS	90 DAY TOTAL SORTIES	90 DAY TOTAL HOURS
F-15C	7	6.8	17	21.2	17	21.2
F-15D	1	1.9	1	1.9	1	1.9
TOTAL	8	8.7	18	23.1	18	23.1

9. MEDICAL

a. Qualifications

At the time of the mishap, the MP was fully medically qualified for flight duty. AF Form 1042, Medical Recommendation for Flying or Special Operational Duty, and annual Preventive Health Assessment (PHA) were current, in accordance with AFI 48-123, Medical Examinations and Standards, and AFI 44-170, Preventive Health Assessment. (Tab DD-11) The MP's most recent flight physical, performed at Royal Air Force (RAF) Lakenheath on 27 September 2010, determined he was medically qualified for flight duties and qualified for worldwide military duty. He had subsequently been medically cleared for flying duties at Nellis AFB on 11 August 2011. (Tab DD-13) Physical and medical qualifications were not factors in the mishap.

b. Health

Medical record review indicated the MP was in good health and had no recent performance-limiting illnesses prior to the mishap. On the 72-hour medical history completed after the mishap, the MP's health was self-described as "10/Excellent". (Tab DD-3 to 7) The MP suffered only minor abrasions, sustained during his parachute landing fall. (Tab X-3) The MP was medically cleared to return to flying status on 7 November 2011 (14 days after mishap). (Tab DD-15)

c. Pathology/Toxicology

No pathological samples were taken.

Immediately following the mishap, toxicology testing was performed on the MP and 34 other personnel, primarily maintenance personnel involved in the launch of the MA. Blood and urine samples were submitted to the Armed Forces Medical Examiner System (AFMES), Rockville, MD, for toxicological analysis. Testing included carbon monoxide and ethanol levels in the blood and urine screening for drugs.

Carboxyhemoglobin saturations (test for carbon monoxide poisoning) of zero to three percent are expected for non-smokers and three to ten percent for smokers. The carboxyhemoglobin saturation in the blood for the MP was one percent (normal), as determined by spectrophotometry. (Tab DD-9)

Testing was also performed on associated maintenance crew members. The AIB Medical Advisor confirmed all results were normal. (Tab DD-17)

AFMES examined the blood for the presence of ethanol at a cutoff of 20 milligrams per deciliter. AFMES detected no ethanol in the MP's blood. The AIB Medical Advisor confirmed all ethanol results were also negative for the associated maintenance crew members. (Tab DD-17)

Furthermore, AFMES screened the MP's and maintenance crew members' urine for amphetamines, barbiturates, benzodiazepines, cannabinoids, cocaine, opiates and phencyclidine by one of two methods, immunoassay or chromatography. AFMES detected none of these drugs in the MP. Associated maintenance members were negative as well, except for one member who was positive for metabolites of both diazepam and hydrocodone, for which they had valid prescriptions. There was no evidence that carbon monoxide, alcohol, or drugs were causal or substantially contributing factors in the mishap.

d. Lifestyle

There is no evidence that lifestyle factors such as unusual habits, behaviors, or stress on the part of the MP or maintenance crew members, as confirmed by witness testimonies and 72-hour histories, were causal or substantially contributory to the mishap. (Tab DD-4 to 5)

e. Crew Rest and Crew Duty Time

Air Force Instructions require pilots to have proper crew rest, as defined in AFI 11-202, Volume 3, General Flight Rules, dated 22 October 2010, prior to performing in-flight duties. Crew rest is defined as a minimum 12-hour non-duty period before the designated flight duty period (FDP) begins. During this time, an aircrew member may participate in meals, transportation, or rest, as long as he or she has the opportunity for at least eight hours of uninterrupted sleep. Without a waiver, the FDP is limited to a maximum of 12 hours for a single-pilot aircraft. This period begins when an aircrew member reports for a mission, briefing, or other official duty.

A review of the duty cycles of the MP leading up to the mishap indicated that he had adequate crew rest. The MP stated he was well rested and had no complaints or illnesses. The FDP was not exceeded. The MP stated that he did not suffer from undue stress, fatigue, sleep cycle disturbance, or lack of rest prior to or during the mishap sortie. MP fatigue was not a causal or substantially contributing factor in this mishap. (Tab DD-4 to 5)

10. OPERATIONS AND SUPERVISION

a. Operations

The 422 TES is a highly-skilled squadron with a total of 65 experienced pilots, 11 of whom are assigned to the F-15C Division. 10 out of the 11 assigned F-15C pilots are qualified as IPs. (Tab T-3 to 8) At the time of the mishap, the operations tempo of the 422 TES was normal with no indications that this contributed to the mishap. (Tab FF-23 to 24)

b. Supervision

Supervision at the squadron, group, and wing level was sufficient and appeared engaged. AFI 11-202, Volume 2 requires that every mission flown brief Special Interest Items (SII). SIIs during the day of the mishap did not include topics such as Departures and Out-of-Control Situations. (Tabs R-31, V-1.10) It is unclear how much AHC discussion in an external wing tank configuration exists.

The original calculated Operational Risk Management (ORM) level of the mission was GREEN; this is the lowest level of risk and places the authority to continue the mission with the aircraft commander or flight lead. The ORM level was not recalculated for the single-ship AHC mission, but would have remained in the GREEN. (Tab K-8) 15 minutes before step time, the mission was reflowed to an alternate plan based on maintenance availability of jets. (Tabs R-29, V-1.10) The PFL coordinated with the MP and Division Commander to change the mission to a single-ship AHC profile. The PFL and the MP then coordinated a deconfliction plan to use the south portion of the Coyote Bravo airspace. (Tab V-1.9 to 1.10) The original Operations Supervisor on duty was unavailable during the MP's step. Because of this, the PFL, who is a qualified 422 TES Operations Supervisor, stepped the MP to his jet. (Tabs T-4, V-10.5)

11. HUMAN FACTORS ANALYSIS

The *Department of Defense Human Factors Analysis and Classification System* lists potential human factors that can play a role in aircraft mishaps. The following human factors were relevant to this mishap:

a. Causal

No causal factors were identified.

b. Contributory

AE104 Overcontrol/Undercontrol

Overcontrol/Undercontrol is a factor when an individual responds inappropriately to conditions either by overcontrolling or undercontrolling the aircraft/vehicle/system. The error may be a result of preconditions or a temporary failure of coordination.

Overcontrol/Undercontrol was found to be a factor in this mishap. Based on the simulator analysis, it was determined that aggressive application of flight controls by the MP due to the MA configuration, fuel state, and the flight regime it was in would induce a departure and subsequent spin. The MP may not have adequately considered longitudinal application of the stick based on the MA being configured with two tanks versus none.

PC504 Misperception of Operational Conditions

Misperception of Operational Conditions is a factor when an individual misperceives or misjudges altitude, separation, speed, closure rate, road/sea conditions, aircraft/vehicle location within the performance envelope, or other operational conditions, and this leads to an unsafe situation.

Misperception of Operational Conditions was found to be a factor in this mishap. Simulator testing, test pilot experience, and manufacturer analysis show there is usually a period in between when a departure occurs and a spin starts. The period can be longer or shorter based on the specific situation and severity of the departure. In some extreme cases, immediate neutralization actions might not prevent spin entry. These extreme cases may be affected by factors such as aircraft configuration, fuel state, and flight regime. It would be imperative to accurately and rapidly perceive these situations, understand the impact, and prevent and counter any adverse conditions that can lead to out of control situations. The MP may not have adequately judged and interpreted this position within the operational envelope.

c. Non-Contributory

All human factors were considered for their possible contribution to the mishap sequence. There were no significant high interest non-contributory human factors.

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Primary Operations Directives and Publications

- (1) AFI 11-2F-15, Volume 1, *F-15 Aircrew Training*, 7 September 2010
- (2) AFI 11-2F-15, Volume 3, *F-15 Operations Procedures*, 21 July 2004
- (3) AFI 11-202, Volume 1, *Aircrew Training*, 22 November 2010
- (4) AFI 11-202, Volume 2, *Aircrew Standardization/Evaluation Program*, 13 September 2010
- (5) AFI 11-202, Volume 3, *General Flight Rules*, 22 October 2010
- (6) AFI 11-214, *Air Operations Rules and Procedures*, 22 December 2005 incorporating Change 2 dated 2 June 2009
- (7) AFI 11-418, *Operations Supervision*, 15 September 2011
- (8) AFTTP 3-3.F-15C, *Combat Aircraft Fundamentals, F-15C*, 1 December 2008 incorporating Change 1
- (9) NAFBI 11-250, *Local Flying Procedures*, 2 October 2009
- (10) T.O. 1F-15A-1, *Flight Manual*, 15 February 2009 incorporating Change 3 dated 1 May 2011
- (11) T.O. 1F-15A-1CL-1, *Flight Crew Checklist*, 15 February 2009 incorporating Change 3 dated 1 May 2011
- (12) 57th Wing Inflight Guide, 1 September 2010
- (13) 57th Wing Inflight Guide, F-15C Supplement, 7 April 2009

b. Maintenance Directives and Publications

- (1) AFI 21-101, *Aerospace Equipment Maintenance Management*, 26 July 2010
- (2) AFI 21-124, *Oil Analysis Program*, 8 December 2010
- (3) T.O. 00-20-1, *Aerospace Equipment Maintenance Inspection, Documentation, Policies and Procedures*, 1 September 2010
- (4) T.O. 33-1-37, *Joint Oil Analysis Program Laboratory Manual, Volume I*, 15 September 2011
- (5) T.O. 42B1-1-1, *Quality Control of Fuels and Lubricants*, 1 August 2004 with Change 1 dated 1 June 2005
- (6) T.O. 42B6-1-1, *Technical Manual -- Quality Control of Aviator's Breathing Oxygen*, 30 April 2004
- (7) T.O. 1F-15A-6, *Supplement -6S-3, Inspection and Maintenance Requirements Manual*, 1 March 2011 with supplement date 28 September 2011

c. Medical Directives and Publications

- (1) AFI 48-123, *Medical Examinations and Standards*, 24 September 2009
- (2) AFI 44-170, *Preventive Health Assessment*, 10 December 2009
- (3) *Department of Defense Human Factors Classification System*, 11 January 2005

d. Known or Suspected Deviations from Directives or Publications.

It has been assessed that the MP probably exceeded 30 CPU with the landing gears down while pulling up from the dive during the spin recovery. The T.O. prohibits exceeding 30 units of AOA with the gear down. The Board President determined this deviation was unintentional due to the ground rush experienced by the pilot. (Tab AA-24) Additionally, the Board President finds this requirement contradictory with the T.O. recommendation to lower the gear since the aircraft will be above 30 CPU in a spin.

The MP did not initiate ejection at or above 6,000 feet AGL while in uncontrolled flight. T.O. 1F-15A-1, Chapter 3, Out of Control/Departure Recovery says, "If recovery is not apparent by minimum recommended ejection altitude (6,000 feet AGL) – [Step] 9. Eject." Where the guidance speaks to ejection altitudes, it is a recommended altitude if out of control. The Board President determined that the MP elected to go below his uncontrolled ejection minimums during the spin because he misperceived his altitude above the ground while simultaneously recognizing that the aircraft was starting to recover from the spin. (Tab AA-20) The MP's testimony states the MA then recovered in a situation where he could transition to controlled bailout altitudes (2,000 feet AGL). (Tab V-1.26) The subsequent recovery led to a nose slice which put the MP below uncontrolled ejection altitudes for a second time (due to no fault of his own), after which he initiated ejection.

NOTICE: The Air Force Instructions listed above are available digitally on the AF Departmental Publishing Office Internet site at <http://e-publishing.af.mil>.

13. NEWS MEDIA INVOLVEMENT

The Nellis AFB Public Affairs Office responded to media interest with an initial press release on 24 October 2011, the date of the mishap. The mishap was reported in television and print local and national media on 24 October 2011, including the *Las Vegas Review-Journal* and Associated Press. Follow up stories appeared in the *Air Force Times*, *Air Force Magazine Online*, *Nellis AFB News*, and other venues. On 30 November 2011, the Air Force News presented a follow up story on the crash recovery and wreckage relocation efforts. (Tab LL-29)

14. ADDITIONAL AREAS OF CONCERN

There are no additional areas of concern.

15. SIGNATURE AND DATE

30 December 2011

DYLAN T. WELLS, Lt Col, USAF
President, Accident Investigation Board

STATEMENT OF OPINION
F-15C, T/N 80-0041 ACCIDENT
24 OCTOBER 2011

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

1. OPINION SUMMARY

On 24 October 2011 at approximately 1600 local time, an F-15C aircraft, tail number 80-0041, departed controlled flight while the mishap pilot (MP) attempted to perform a defensive break turn followed by a high-speed heading reversal during a single-ship sortie. The mishap aircraft (MA) entered into a flat counterclockwise spin from a starting altitude of approximately 19,000 feet mean seal level (MSL). The MP attempted to regain control of the MA, employed required Spin Recovery Display (SRD) controls of full lateral stick to the left, attempted to apply neutral longitudinal stick, and placed throttles to military and idle power settings for left and right engines respectively. After descending to approximately 13,000 feet MSL without noticeable change in spin characteristics, the MP lowered landing gear IAW the F-15C flight manual. Lowering the landing gear appeared to aid in MA spin recovery. Recovering out of the spin, the MA settled into a 60-70 degrees nose low attitude to regain flying airspeed at a cockpit observed altitude of 8-9,000 feet MSL (equating to 4-5,000 feet above ground level (AGL)). The MP selected afterburner on both engines to attempt a nose low dive recovery from the MA's low energy state. Nearing the horizon in this dive recovery, the MA "departed" again with a second nose slice to the left. The MP transitioned from a controlled situation (and ejection altitude of 2K feet AGL) to being below the allowed uncontrolled ejection altitude (6K feet AGL) again, forcing subsequent MP ejection. The plane crashed into an uninhabited area of the Nevada Test and Training Range (NTTR) owned by the Bureau of Land Management (BLM). The MP ejected without serious injury, the MA was completely destroyed, and neither any NTTR infrastructures nor BLM structures were damaged.

The MA was not equipped with a crash-survivable flight data recorder. Additionally, the MP failed to power two other recording systems and did not enter into the local Fighter Data Link (FDL) network. The most reliable evidence found was MP testimony, local airspace control facilities radar plots of the MA's initial maneuvering, and pictures taken late in the mishap sequence by a civilian who happened to be observing the MA's maneuvers. The post-mishap analysis of all aircraft components (control surfaces, actuators, etc.) and hydraulic and oil servicing appeared normal. Likewise, nothing in the MP testimony was singularly causal. Given this lack of evidence from potential sources, I was not able to determine a root cause by clear and convincing evidence. However, I did identify six factors that by a preponderance of evidence substantially contributed to the mishap. It is worth emphasizing that the six contributing factors, although discrete events, have interrelated elements as well. It is also important to note that eliminating any one of the six contributing factors would have stopped the mishap occurrence. That does not necessarily mean they are additive but does mean they need to occur in sequence.

2. DISCUSSION OF OPINION

I aligned these six contributing factors with four time elements in the mishap sequence to better highlight their relevance and contribution to the mishap sequence. That relationship is below. First were factors that contributed to an initial departure. These included aircraft structural imperfections, inadequate discussion of Advanced Handling Characteristics (AHC) topics, and a misapplication of flight controls. Second were factors that allowed the departure to progress into a spin. This involved a misperception of the operational conditions, which manifested into a lack of recognition of either the impending spin or how quickly departures can transition into a spin. The third area involved factors that prevented spin recovery until below established uncontrolled ejection timelines. This included an inability to attain and maintain full aileron and stabilator authority at lower-spin yaw rates. Additionally, this area involved balancing known operational risks between 1) maneuver starting parameters; 2) requirements to train in regimes where aircraft performance is maximized; and 3) the reduced altitude available to recover from any out of control situations that develop – the latter exacerbated by the low-rate spin recovery issues mentioned. Ultimately, spin recovery was aided by lowering the landing gear which reduced washout, increased control surface authority and lowered overall yaw rate. However, this limited follow-on maneuvers – specifically the maneuver that led to the second departure in a low altitude environment. This fourth element, the final “end-game departure,” was actually not a classic aircraft departure. Aggressive aft control stick pull, lower airspeed, lower altitude, higher dive angle, and gear down dive configuration led to a situation where the aircraft did not have airspeed and authority for the requested maneuver. The nose slice to the left is a reaction to this state. In this nose slice, the MA reentered below uncontrolled ejection altitudes. Since the MP should have ejected prior to beginning maneuvers that lead to the nose slice, it was not considered a contributory factor and is not further analyzed.

F-15C 80-0041 Mishap, Root Cause, Contributing Factor, Key Event Synch Matrix	
<u>Root Cause</u>	<u>Role to Key Event</u>
None	Not Applicable
<u>Contributing Factor</u>	<u>Role to Key Event</u>
Aircraft Structural Imperfections	Factor that Led to Initial Departure
Inadequate Focus on AHC Topics	Factor that Led to Initial Departure
Misapplication of Flight Controls	Factor that Led to Initial Departure
Misperception of Operational Conditions	Factor that Aided the Departure Progressing to a Spin
Reduced Control Authority In Low Rate Spins	Factor that Prevented Recovery by Ejection Altitudes
Institutional Operational Risk Balancing	Factor that Prevented Recovery by Ejection Altitudes
All of the Above	Factor(s) that Led to Second "Departure"/Nose Slice*
*NOTE: The 2nd "Departure"/Nose Slice is not contributory to the mishap since ejection altitude were previously met	

After ruling out flight control system failures as a factor through the MP testimony and testing of flight control systems, radome imperfections were identified as a likely contributor. In high AOA situations, they can produce a large enough yaw moment to drive a departure. (Tab KK-41) The mishap sequence as described by the MP was consistent with a radome imperfection. During our simulator testing, it was nearly impossible to create a departure like the one the MP described without

introducing a radome imperfection. These imperfections can be invisible to the naked eye and have been estimated to be present in over 50% of F-15 radomes. (Tab KK-18) Further, during a recent post-mishap survey of Nellis AFB radomes, I observed many radomes with imperfections similar to those documented in engineering studies. (Tab CC) A preponderance of evidence supports radome imperfection as being substantially contributory.

Another factor that led to MA departure was an inadequate focus on AHC topics prior to flight. Numerous witnesses indicated that AHC was briefed as an alternate mission—a proper option when available aircraft numbers are reduced. However, that brief item did not translate into proper actions once it was known that a single aircraft would be flown. The MP needed to spend more time choosing AHC maneuvers, the mechanics involved, and implications of fuel weight and aircraft configuration on the AHC profile developed.

Misapplication of flight controls, likely due to the AHC focus issues above, was a human element in the departure chain. The MP testimony recounted an aggressive approach to the break turn and the level reversal. The rapid unload and onset rates could create a high AOA situation that can lead to a departure, especially with a combination of radome imperfections, low fuel weights, and external fuel stores. This scenario was reproduced through a variety of entry regimes during Boeing simulation. Profile results are attached. (Tab HH)

The factor contributing to the departure progressing to a spin (a more complex yet generally recoverable situation) was a misperception of existing operational conditions. This could have occurred in two ways. The first way is either not recognizing departure cues, some of which are the same tone used for other cockpit cues, in adequate time. Likewise, failure to apply corrective actions (neutralization of controls) properly or quickly enough will have the same effect. This scenario was reproducible during Boeing simulation and consistently led to a spin. (Tab GG) A second way this misperception could occur is for departure conditions to be so severe that there is no perceivable gap in the continuum from a departure to spin. This situation better matches pilot testimony; however, it could not be recreated during our simulator runs. That does not mean the MP testimony was inaccurate, but rather places emphasis on how close departure and spin regimes could be. It also highlights how important understanding operational conditions are and how dangerous the MP's rapid loading and unloading could be in that environment.

Not attaining or maintaining full control surface authority contributed to an inability to recover from the spin prior to reaching ejection altitudes. The first way this could happen is through misapplication or late flight control input. Without further evidence it is impossible to attest to the timing; however, endgame images show proper flight control deflections for the spin encountered. (Tab S-15) It is my opinion that his application of anti-spin controls occurred quickly after the SRD appeared and certainly within the delays utilized during simulator testing. A second way to not attain full control surface authority is to be in a low-rate spin. With a yaw-rate of less than 60 degrees/sec, F-15C design characteristics limit full aileron and stabilator authority – to a greater degree as the stick is moved farther from neutral. The MP's stated parameters led to these low-rate spins on all but two spins reproduced. Likewise, this expected control surface washout was routinely modeled during simulation and delayed recoveries by 2,000-5,000 feet. Lowering the landing gear allowed full control authority regardless of stick position. Just as was the case in the mishap sequence, extended gear helped recover a spin in the simulator – generally within 3-4 revolutions. (Tab GG) It also

consistently resulted in a nose low attitude (50-60 degrees) which required careful flight control application to facilitate subsequent maneuvering. Certainly, higher surface terrain and associated ejection altitudes exacerbated this and decreased the ability to recover in time. Ironically, 12 mechanical failures were applied in our simulator runs and only 2 (both of which were unrecoverable) had a greater effect than not attaining full control authority. (Tab HH)

Finally, Air Force-accepted risk placed the MA in a regime with decreased ability to recover by recommended ejection altitudes from the start. This is not a bad thing, and in truth, is required. To fully understand aircraft capabilities and how to max-perform them, pilots need to operate in certain regimes. Many of these regimes are below 20,000 feet MSL. These skills are critical to overall proficiency, especially for air-to-air dominance platforms, like the F-15C. Contrastingly, spin testing and recoveries, in a controlled environment, generally begin above 30,000 feet MSL. (Tab KK-19) A correct assessment of risk was made by supervisors to allow the AHC mission, especially since it is rare that events would align to prohibit recovery. But they can align as evidenced by this mishap. Tactical aviation must balance risks and not all risks can be fully mitigated.

3. CONCLUSION

In summary, I was not able to determine a root cause but did find six factors substantially contributing to the mishap. My findings led to three final thoughts I want to convey. First, the fact that so little evidence survived eliminates any ability to pigeon-hole the mishap sequence into a singular cause that “derails the train.” In some respects that is a very good thing. It was impossible to objectively prioritize contributing factors into an ordered list showing accident causality. I could have developed numerous “chicken or the egg?” scenarios. Did low emphasis of AHC profile specifics create a situation where the MP was too aggressive, or did a greater radome imperfection than expected lead to greater probability of entering into unexpected regimes and merit an expanded AHC discussion in the pilot’s element brief? I have analyzed and reanalyzed these questions and find them impossible to answer. Second, it takes the perfect storm for this mishap to happen. Had the MA not had external wing tanks, I believe the mishap would have not occurred. Had this been earlier in the sortie, I believe the same is true. If the MA had less severe radome imperfections, the MA would not have departed. Had the spin-rate been consistently greater or longitudinal neutral more precisely achieved, the recovery may have occurred prior to ejection altitudes. There was a mishap due to a unique alignment in sequence, time, and interrelationship--all had to occur for the chain to be complete. The final conclusion is this perfect storm will happen again. It is clearly unique but, given the right circumstances, repeatable. It is also clearly preventable but takes a coordinated effort and continued collaboration between the user and manufacturer and from General to Airman, since the contributing factors cover such a broad scope.

DYLAN T. WELLS, Lt Col, USAF
President, Accident Investigation Board