EXECUTIVE SUMMARY
F-15D 85-0131
AIRCRAFT ACCIDENT INVESTIGATION BOARD
NELLIS AIR FORCE BASE, NEVADA
30 July 2008

On 30 July 2008 at approximately 1117 Local (Pacific Daylight Time), F-15D serial number 85-0131 assigned to the 65th Aggressor Squadron, 57th Wing at Nellis Air Force Base, departed controlled flight and spun while executing a planned maneuver during exercise Red Flag 08-3. The aircraft impacted the ground 20 miles northwest of Rachel, Nevada in an uninhabited area on the Nevada Test and Training Range (NTTR) belonging to the Bureau of Land Management. Both aircrew ejected. The back seat observer pilot sustained minor injuries and was rescued; the front seat pilot hit the ground before his parachute fully deployed and died immediately upon ground impact. The aircraft and associated equipment were destroyed with the aircraft loss valued at $38,003,021. There were no civilian casualties or additional damage.

The Board President found by clear and convincing evidence this mishap was caused by a sudden departure from controlled flight during a routine maneuver when the mishap pilot momentarily exceeded the allowable angle of attack. Through extensive simulation, he found each of the following factors substantially contributed to the mishap: (1) an external wing fuel imbalance of at least 750 pounds; (2) F-15D left yaw/roll phenomenon when configured with two external wing tanks; and (3) a radome (nose cone) imperfection. After the mishap pilot recovered the aircraft from the spin, spatial disorientation hampered the dive recovery. The Board President found clear and convincing evidence that at low altitude, this spatial disorientation was also causal to the mishap and ultimately led to the mishap pilot's death.

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 an aircraft accident, nor may such information be considered an admission of liability of the United States or by any person referred to in those conclusions or statements.

SUMMARY OF FACTS AND STATEMENT OF OPINION
F-15D ACCIDENT
30 July 2008

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COMMONLY USED ACRONYMS & ABBREVIATION

ACaP	Advanced Capability Pod
ACC	Air Combat Command
ACES II	Advanced Concept Ejection Seat
ACM	Air Combat Manuever
AF	Air Force
AFB	Air Force Base
AFI	Air Force Instruction
AFIP	Armed Forces Institute of Pathology
AFPAM	Air Force Pamphlet
AFTO	Air Force Technical Order
AGL	Above Ground Level
AGRS	Aggressor Squadron
AIB	Accident Investigation Board
AMU	Aircraft Maintenance Unit
AOA	Angle of Attack
ARI	Aileron Rudder Interconnect
ATC	Air Traffic Controller
BFM	Basic Fighter Manuever
CAS	Control Augmentation System
CPU	Cockpit Units
CT	Continuation Training
DO	Director of Operations
ELT	Emergency Locater Transmitter
EP	Emergency Procedure
EPS	Emergency Power Supply
FAIP	First Assignment Instructor Pilot
FCIF	Flight Crew Information File
FEF	Flight Evaluation Folder
FS	Flight Surgeon
G	Gravitational Load Factor
HPO	Hourly Post Flight
HUD	Heads Up Display
IAW	In Accordance With
IMDS	Integrated Maintenance Data System
INS	Inertial Navigation System
JMPS	Joint Mission Planning System
JHMCS	Joint Helmet Mounted Cueing System
KIAS	Knots Indicated Airspeed
KIO	Knock It Off
L	Local Time
MA	Mishap Aircraft
MAJCOM	Major Command
MC	Mishap Crew
MOA	Military Operating Area
MP	Mishap Pilot
MSL	Mean Sea Level
NACTS	Nellis Air Combat Training System
NTTR	Nevada Test and Training Range
OP	Observer Pilot
Ops	Operations
PRCA	Pitch Roll Channel Assembly
RAF	Royal Air Force
ROE	Rules of Engagement
RTB	Return to Base
SAR	Search and Rescue
SEFE	Standardization Evaluation Flight Examiner
SF	Standard Form
SI	Special Instruction
S/N	Serial Number
SOF	Supervisor of Flying
SPO	Systems Program Office
SRD	Spin Recovery Display
TCTO	Time Compliance Technical Order
TDY	Temporary Duty
T.O.	Technical Order
UHF	Ultra High Frequency
USAF	United States Air Force
U.S.C.	United States Code
VSD	Vertical Situation Display
Vol.	Volume
Z	Zulu or Greenwich Meridian Time (GMT)

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

SUMMARY OF FACTS

1. AUTHORITY, PURPOSE, AND CIRCUMSTANCES

a. Authority.

On 31 July 2008, General John D. Corley, Commander, Air Combat Command (ACC), appointed Brigadier General Robert P. Otto to conduct an aircraft accident investigation of the 30 July 2008 crash of an F-15D aircraft, serial number (S/N) 85-0131, on the Nevada Test and Training Range, approximately 105 miles northwest of Nellis AFB, Nevada. The investigation was convened under Air Force Instruction (AFI) 51-503 and was conducted at Nellis AFB, Nevada, from 2 September 2008 through 30 September 2008. Technical advisors were Lieutenant Colonel Elizabeth H. Lowe (Medical), Lieutenant Colonel Margarete P. Ashmore (Legal), Lieutenant Colonel Michael R. Quintini, Jr. (Weapon Systems Officer), Major Clinton F. Warner (Pilot), Master Sergeant Mary S. Moten (Recorder), Technical Sergeant Russell A. Foley (Court Reporter), and Technical Sergeant Nicholas A. Noethe (Maintenance) (Tabs Y-2, Y-3).

b. Purpose.

The purpose of this investigation was to provide a publicly releasable report of the facts and circumstances surrounding the accident, to include a statement of opinion on the cause or causes of the accident; to gather and preserve evidence for claims, litigation, disciplinary and adverse administrative actions; and for other purposes. The report is available for public dissemination under the Freedom of Information Act (5 United States Code (U.S.C.) sec. 552) and the Air Force Supplement to Department of Defense (DoD) Regulation 5400.7, *Department of Defense Freedom of Information Act Program.*

c. Circumstances.

The mishap crew was flying a two-seat F-15D as number three in a three-ship of F-15s. These three F-15s plus eight F-16s were providing defensive counter air while simulating Red Air tactics against a large force of 26 Blue Air aircraft on day eight of ten in red Flag 08-3. The vulnerability period had just begun and the mishap aircraft was 40 miles from the nearest adversary (Tab H-3, AA-4). The mishap aircraft, S/N 85-0131, was assigned to the 65th Aggressor Squadron, 57th Wing, Nellis AFB, Nevada (Tab C-3).

2. ACCIDENT SUMMARY

On 30 July 2008 at 1817Z (1117 Pacific Daylight Time), aircraft F-15D, serial number 85-0131, departed controlled flight while executing a planned maneuver during exercise Red Flag 08-3 and impacted the ground 20 miles northwest of Rachel, Nevada in an uninhabited area on the Nevada Test and Training Range (NTTR) belonging to the Bureau of Land Management (Tab B-

3). The mishap pilot (MP), Lieutenant Colonel Thomas Bouley, was fatally injured in the accident (Tab X-2). The observer pilot (OP), a Royal Air Force Flight Lieutenant, ejected safely and was recovered with minor injuries (X-3). The aircraft was totally destroyed upon impact with the loss valued at $38,003,021.34 (Tab P-3). Total USAF aircraft, equipment damage and cleanup costs are valued at $50,000,000 (Tab P-6). Other than the loss of the aircraft and equipment, there was no damage to government property and there were no civilian casualties. The mishap was reported in the local and national media at the time it occurred (Tab FF-2 thru FF-8). Media interest has been minimal since the story was first reported.

3. BACKGROUND

a. 57th Wing.

The 57th Wing, located at Nellis AFB, provides advanced combat training to world-wide combat air forces. The wing is comprised of 57th Operations Group (OG), 57th Adversary Tactics Group (ATG), and 57th Maintenance Group. The 57th OG directs the execution of Red Flag, a comprehensive, two-week long air combat training and preparation exercise. Red Flag is conducted by the 414th Combat Training Squadron on the Nevada Test and Training Range and traditionally involves numerous USAF and allied tactical and support aircraft. In a typical Red Flag exercise, Blue Forces (friendly) engage Red Forces (enemy) in combat situations. Red Forces, assigned to the 57th ATG, are comprised of the 64th and 65th Aggressor Squadrons, flying F-16s and F-15s, respectively. Their mission is to support joint and allied aircrew training by replicating enemy threat systems and tactics, training, test support, academics and feedback. The 57th Wing and its subordinate units are components of the United States Air Force Air Combat Command (ACC) (Tabs GG 7 thru GG-9).

b. 99th Air Base Wing.

The 99th Air Base Wing is the host unit at Nellis AFB, Nevada. It oversees the daily operations of the base to include personnel, finance, civil engineering and supply. The three groups assigned to the wing are 99th Medical Group, 99th Mission Support Group and 99th Security Forces Group. The 99th Medical Group provides a wide range of medical care for the military community similar to a community hospital (Tab GG-18).

4. SEQUENCE OF EVENTS

a. Mission.

The mishap mission was to provide Red Air support during exercise Red Flag 08-3. The mishap aircraft (MA) was number three of a three-ship element of F-15C/D aircraft from the 65th Aggressor Squadron (AGRS), Nellis AFB, Nevada, in a larger, eleven-ship Red Force package. The remaining eight aircraft were F-16 aircraft from the 64th AGRS, Nellis AFB, Nevada. The mission took place in the Nellis Test and Training Range located north of Nellis AFB (Tab H-3, AA-4).

The mishap aircraft element, callsign Flanker 1 flight, was to depart Nellis AFB at 1705Z (1005 local time) followed by two separate elements (four aircraft each) of F-16 aircraft, callsigns MiG 1 flight and MiG 5 flight, respectively. Each of the elements was planned to rendezvous with a tanker to air refuel. Once complete with air refueling the individual elements would proceed to their designated hold points until the start of the vulnerability period. At the start of the vulnerability period the individual Red Force elements would flow east, executing pre-briefed tactics, to provide air-to-air opposition to the ingressing Blue Force fighters as they flowed west. The Blue Force fighters would strike targets and then depart back to the east, while Red Forces were to engage Blue Forces as they departed. In addition to the air-to-air training, several elements of the Blue Force fighters planned to drop live air-to-ground munitions as part of their mission. At the end of the vulnerability period, if sufficient fuel remained, the individual Red Force elements were to rejoin for pre-briefed alternate missions. Upon completion of the alternate missions, each element was to return to Nellis AFB separately (Tab AA-4).

The mishap pilot (MP) was an active duty USAF pilot at the time of the mishap. He was scheduled to fly a two seat F-15D for this mission (Tab B-3). He was a current and qualified Standardization Evaluation Flight Evaluator (SEFE) in the F-15 and was the squadron commander of the 65th AGRS (Tab AA-2). The observer pilot (OP) was an active duty Royal Air Force exchange pilot. He was in upgrade training in the 64th AGRS flying F-16 aircraft (Tab V-4). The mishap sortie was his second sortie in the F-15D and was a familiarization sortie (Tab V-4). The flight was properly authorized in accordance with (IAW) Air Force Instruction 11-401, *Aviation Management*. The daily operations supervisor authorized the flight on behalf of the squadron commander IAW squadron policy (Tab K-4).

b. Planning.

Mission planning included a Red Flag mass briefing, a Red Force coordination briefing, an F-15 element briefing and the mishap crew coordination briefing. The Red Flag mass briefing and Red Force coordination briefing were conducted by MiG 1, the overall Red Force flight lead. All Red Force flight members attended the briefings. The briefings were conducted in accordance with all applicable directives. The mass briefing started on time. Flight members indicated minimum ejection altitudes were covered (6,000 feet uncontrolled above ground level, 2,000 feet controlled above ground level) in the Red Force coordination briefing (Tab R-19, V-6). Flight members also indicated the briefings were thorough and the mission was fully understood by all the members of the Red Force flights (Tab R-3, R-19, V-6).

The F-15 element briefing was conducted by Flanker 1. It addressed F-15C/D specific items. Flight members indicated the briefing was thorough and the mission was understood by all Flanker flight members (Tab V-6).

The mishap crew coordination briefing was conducted by the mishap pilot. The briefing was conducted in accordance with all applicable directives. The briefing addressed the exchange of aircraft control between front and back seater, the plan to get the observer pilot some time flying the aircraft (holding time before the vulnerability period), the overall tactical game plan, and the ejection seat command selector valve setting for the rear cockpit (AFT initiate) (Tab V-8). The AFT initiate setting allows the ejection sequence to be initiated from either seat and will result in

a dual ejection sequence (both aircrew would be ejected from the aircraft), rear seat first (Tab H-5, BB-8). No discussion took place regarding specific minimum ejection altitudes (Tab V-6 thru V-7).

c. Preflight.

The mishap crew was given a pre-step briefing by the squadron supervisor and then stepped to the aircraft on time. Upon arrival at the aircraft, the MP reviewed the aircraft forms and conducted a pre-flight walk-around inspection to assess airworthiness. Nothing unusual was noted during the pre-flight walk-around inspection, start and taxi to the runway. There were no abnormal maintenance actions required to the aircraft prior to takeoff. The observer pilot set the ejection seat command selector valve setting to AFT initiate in accordance with the mishap crew coordination briefing (Tab V-8).

d. Flight.

Takeoff and departure, air refueling and entry into the Nevada Test and Training Range (NTTR) were uneventful (Tab V-9). Upon arriving in the NTTR, Flanker flight completed several routine flight checks. One of the checks was the G-awareness exercise (Tab L-3). The G-awareness exercise is executed to ensure both the aircraft and aircrew are prepared for the high G environment associated with air-to-air combat. The exercise consists of two 180 degree turns during which various G levels are achieved. During the second turn of the G-awareness exercise, with fuel still remaining in the external wing tanks, Flanker 3 exceeded 30 cockpit units angle-of-attack for approximately 0.7 seconds (Tab L-3).

Angle-of-attack (AOA) is the angle between the relative wind direction and the aircraft wings. The F-15C/D does not display AOA directly. Instead, it displays AOA as cockpit units (CPU) on a scale of 0 through 45. AOA is displayed on a gauge in the cockpit and in the Heads-Up-Display (HUD) (Tab BB-4). 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. CPUs are roughly equivalent to actual AOA plus 10 degrees (Tab BB-15). Normal maneuvering range is from approximately 8 to 30 CPU. High AOA is considered to be above 30 CPU. With fuel in the external fuel tanks, the F-15C/D is limited by technical order to a maximum of 30 CPU (Tab BB-13). This restriction was put in place to mitigate the risk of departure (a large, uncommanded flight path change) due to imbalanced fuel in the external fuel tanks.

No high AOA warning tone sounded as 30 CPU was exceeded during the G-awareness turn (Tab L-3). The high AOA warning tone sounds to cue the pilot when the programmed AOA is exceeded (Tab BB-4). If there are external fuel tanks on stations 2 and 8 (wing pylons), as was the case with the mishap aircraft, the system defaults to 30 CPU warning tone at power-up to aid the pilot in adhering to the technical order restriction (Tab BB-4). It will remain at 30 CPU unless it is reprogrammed by the data transfer module during data transfer or if it is manually changed by the pilot (Tab BB-4). The 65th Aggressor Squadron standard data transfer module load for Red Flag sorties retains the 30 CPU high AOA warning setting and therefore would not have changed the MA default 30 CPU setting (Tab R-6, V-62). Since the AOA warning tone did

not sound, the mishap pilot must have manually reprogrammed the high AOA warning tone setting. Witness testimony and standard F-15C/D practice would make this an unusual technique given the mission and configuration of the aircraft (Tab R-6, V-63).

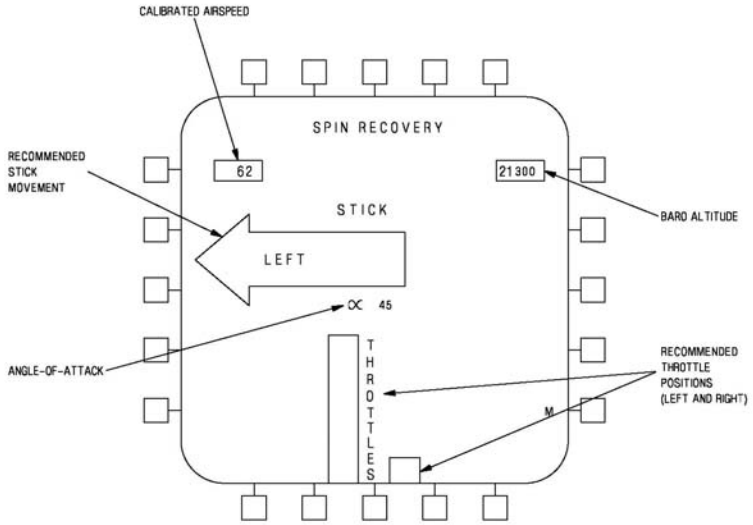
Upon completion of the G-awareness exercise Flanker flight entered holding at a fuel conserving airspeed until just prior to the vulnerability period (Tab N-5). Two fuel checks were conducted during this time. During the first fuel check, Flanker 1 indicated he had 20,100 pounds of total fuel and his external wing tanks were balanced. Flanker 2 responded he had 19,200 pounds of total fuel and his external tanks were imbalanced 2,000 pounds left heavy. The mishap pilot stated, "D'oh" over the mishap aircraft intercom upon hearing about Flanker 2's fuel imbalance and then responded he was "same as one" via the mishap aircraft auxiliary UHF radio (Tab N-5). "Same as one" indicated he had the same total fuel as Flanker 1 and his external tanks were balanced. The second fuel check occurred approximately 14 minutes and 30 seconds later. During this fuel check, Flanker 1 indicated he had 17,700 pounds of total fuel with his external wing tanks balanced. Flanker 2 responded he had 17,000 pounds of total fuel, and he was 2,500 pounds imbalanced left heavy. The mishap pilot gave a non-standard response of "three same" (Tab N-5). Flanker 1 and 2 both noted this response and interpreted it to mean Flanker 3 had the same fuel state as Flanker 1 (17,700, balanced) (Tab R-4, R-5, R-18). They interpreted his response in this manner because his previous fuel check response indicated his total fuel and balance were the same as Flanker 1's (Tab R-4, R-5, R-18). Because the three aircraft flew in formation the entire time between fuel checks, their total fuel consumed would have been roughly equivalent (2,400 pounds). In addition, in order to have achieved a fuel imbalance equivalent to Flanker 2's, the mishap aircraft's left tank would have had to stop feeding almost immediately following the last fuel check. Flanker 1 and 2 judged this highly unlikely (Tab R-5, R-18). This was the last fuel check accomplished prior to the mishap which occurred 12 minutes later. (Tab N-5)

At approximately 1815Z (1115 local time), the mishap aircraft started east in accordance with the briefed plan (Tab L-3). At approximately 1816:30Z the mishap pilot initiated a pre-planned level turn to the south (Tab L-3). Upon reaching a heading of 160 degrees he rolled out to wings level and continued in level flight for approximately five seconds (Tab L-3). At 1817:04Z the mishap pilot executed a 1 G (one times the force of gravity), left roll to wings level inverted as part of a pre-planned combat descent to 3,000 feet AGL (Tab L-3). This is a very common technique for fighter aircraft to execute an expeditious descent. At the start of the maneuver the mishap aircraft was at 31,500 feet above mean sea level (MSL), 317 knots and had approximately 15,700 pounds of fuel remaining (Tab M-7). This estimated fuel load would leave approximately 1,900 lbs of fuel in the external wing fuel tanks. Both the observer pilot and the recovered tapes from the mishap aircraft confirmed there was no discussion between the mishap pilot and observer pilot regarding any fuel quantity abnormalities or fuel imbalance (Tab L-3, V-9, V-10). Upon reaching wings level inverted, the mishap pilot initiated a smooth, straight, energy sustaining pull achieving approximately 3 – 3.7 Gs and 30 – 34 cockpit units angle-of-attack (Tab L-3, M-7).

At 1817:08Z, as the mishap pilot approached 60 degrees nose low, wings level, inverted, the mishap aircraft experienced a slight left yaw and right wing drop followed by a rapid, left yawing and rolling moment and departed controlled flight (Tab L-3, M-7). The cockpit

indications from the mishap aircraft Vertical Situation Display (VSD) tape indicate the start of yaw at time 1817:08Z which is accompanied by 1 – 2 yaw warning tones (the warning tone sounded when the yaw rate reached 30 degrees per second) (Tab L-3, BB-4). The mishap pilot commented a surprised "Whoa, that's not good" after the first beep was heard (Tab N-7). Less than one second after the first indication of yaw, the Spin Recovery Display (SRD) appeared on the VSD indicating the aircraft detected a spin condition (Tab L-3, BB-6). The SRD displayed SPIN RECOVERY, AOA, calibrated airspeed and barometric corrected altitude (Tab BB-7). An arrow indicated stick position and throttle position bars indicated recommended throttle placement (Tab BB-7). See Figure 1 for a representative spin recovery display. Again, no high AOA warning tone sounded prior to departure (Tab L-3). This was likely due to manual reprogramming.

Figure 1. F-15C/D Spin Recovery Display (Tab BB-7)



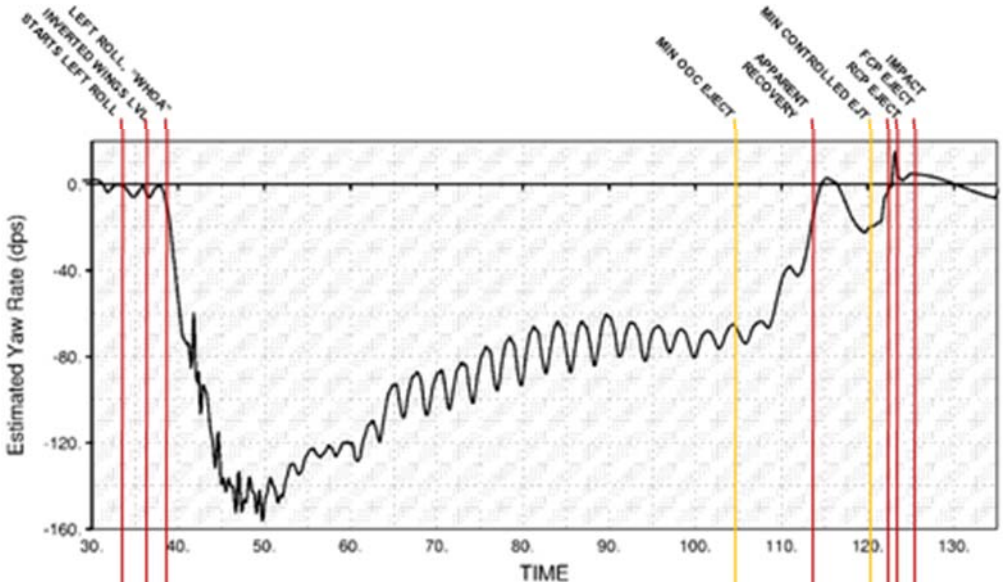
At the start of the yaw the mishap aircraft was at 30,800' MSL and the observer pilot reported he was looking over his left shoulder watching an F-16 from another flight as the mishap pilot pulled aft on the stick. He stated that he felt a slight yawing sensation as the nose hit its lowest point. The yawing sensation was significant enough to draw the observer pilot's attention forward. As he turned his head, he observed a right wing drop followed by a violent yawing and rolling moment to the left (Tab V-19). Over the course of the next second, the yaw rate increased through 50 degrees per second and continued to climb over the next 10 seconds to approximately 160 degrees per second (Tab M-7). By way of comparison, most documented F-15C/D spins reach a maximum yaw rate of approximately 130 degrees per second. The observer pilot stated the "eyeballs-out" forces were so violent he was thrown forward during the departure and was held in place by the shoulder straps at their max extension point (Tab V-13). At the highest point, the observer pilot experienced approximately -4 Gs of "eyeballs-out" force while the

mishap pilot experienced approximately -5.5 Gs (Tab M-7). The mishap aircraft settled into an upright, flat spin (Tab V-11 thru V-13).

At 1817:30Z while established in an upright, flat spin, the mishap pilot transmitted a "Knock-It-Off" call via the mishap aircraft primary UHF radio (Tab N-7). Immediately following the call, the mishap pilot requested altitude awareness calls from the observer pilot via the mishap aircraft intercom (Tab V-13 thru V-14). The observer pilot interpreted this to mean he should call altitudes off the altimeter, and he recalls making his first calls of 21,000 and 20,000 feet (Tab V-13 thru V-14). The T.O. 1F-15A-1 states that as AOA increases between 35 and 40 CPU, the indicated barometric altitude will start becoming erroneous and can read as much as 1,500 feet higher than the aircraft's actual altitude (Tab BB-19). Given the AOA during the spin, the altitudes being displayed to both the observer pilot and the mishap pilot were occasionally up to 1,500 feet MSL higher than the aircraft's actual altitude (Tab L-3).

Figure 2. Plot of mishap aircraft yaw rate, 1817:00Z thru 1818:36Z (Tab CC-9).

Note: Time 1817:00Z equals 30 on time scale. Time is in seconds. Left yaw is negative.



As the mishap aircraft continued to spin the yaw rate steadily slowed, and then maintained half its peak rate, 46 seconds after the initial departure (Tab M-7). The yaw rate then remained stable for approximately 30 seconds (Tab M-7). As the mishap aircraft passed through approximately 15,000 feet MSL (10,000 feet AGL) the altitude displayed in the SRD began to flash, indicating the mishap aircraft had calculated that it had descended below 10,000 feet AGL (Tab L-3, BB-7). The aircraft's computer approximated this by using the nearest stored navigation point (5,300 feet MSL) (Tabs AA-6, BB-7). This was the only displayed AGL indication available to the mishap pilot. At 1818:14Z and 12,000 feet MSL, the mishap pilot transmitted, "OK, I've got a spin" via the mishap aircraft primary UHF radio (Tab N-8, M-7). Four seconds later, as the

mishap aircraft passed through 10,500 feet MSL, the yaw rate rapidly began to slow and was interpreted by the observer pilot as the mishap aircraft beginning to recover from the spin (Tab M-7, V-14 thru V-15). The observer pilot recalls making altitude awareness calls of 12,000 and 11,000 feet during the attempted recovery (Tab V-15). The observer pilot stated his personal minimum uncontrolled ejection altitude was 10,000 feet MSL (Tab V-16). Based upon his perception, the ground was at 4,000 feet MSL; however, it was really 1,400 feet higher (5,400 feet MSL) (Tab V-16). The mishap aircraft had lost approximately 20,000 feet in the spin and had spun approximately 20 times (Tab M-7). Most recorded F-15C/D spins are two to four rotations (Tab BB-27).

At 1818:24, with the mishap aircraft at approximately 9,200 feet MSL (3,800 feet AGL), 55 degrees nose low and 150 knots the mishap pilot began to recover from the post-spin dive. He made a slight right roll to wings level and began an aft stick pull to bring the aircraft back towards level flight (Tab M-7). The mishap pilot also selected augmentation (afterburner) on both motors (Tab J-Part1-18). The observer pilot was aware they were passing through his personal minimum uncontrolled ejection altitude of 10,000 feet MSL but determined the mishap aircraft was recovering with sufficient altitude remaining (Tab V-18). Approximately 4 seconds later the mishap aircraft began a coordinated left roll at 2,800 feet AGL and continued this roll with decreasing pitch angle until the mishap pilot and the observer pilot simultaneously pulled the ejection seat handles well below the recommended minimum altitude (Tab H-14, M-7). The mishap aircraft was at 700 feet AGL, 70 degrees nose low and in a slight left bank (Tab H-14, M-7). Both crewmembers were ejected from the mishap aircraft by the automatic sequence, with the observer pilot in the rear cockpit ejecting first followed .4 seconds later by the mishap pilot (Tab H-14). The observer pilot survived the ejection with minor injuries while the mishap pilot sustained fatal injuries (Tab H-3). The mishap aircraft impacted the ground two seconds after ejection (Tab M-7). Several seconds later Flanker 1 saw smoke and fire associated with the crash site and assumed responsibility as the on-scene Search and Rescue commander (Tab N-8).

e. Impact.

Aircraft S/N 85-0131 impacted the terrain at approximately 1118:35L at N 37-47.2 W 116-04.8, 5,398 feet MSL (Tab C-3). The aircraft hit 70 degrees nose low in a slight left bank at 25,000 feet per minute descent rate (Tab M-7, II-2). The impact area was a barren desert area owned by the Bureau of Land Management (C-3, Tab J-Part1-3). As a result of the steep vertical descent, all the wreckage, except for the canopy, was confined to a relatively small scatter field (Tab J-Part1-19). After impact, fuel in the aircraft ignited and destroyed significant portions of wreckage (Tab J-Part1-19). There was very little damage to surrounding terrain, with the exception of the impact crater (Tab P-7). There were no civilian casualties (Tab P-7).

f. Life Support Equipment, Egress and Survival.

Both mishap crew members simultaneously initiated an ejection well below the recommended minimum altitude at 1818:33Z/1118:33L. An evaluation of all egress system/life support equipment recovered from the crash site showed all equipment functioned properly. The aft seat catapult first motion was 18:18:33.6Z, followed by the forward seat catapult 0.4 seconds later at 18:18:34.0Z in accordance with designed specifications (Tab H-14).

The mishap crew ejected at 240 knots and 6,142 feet MSL which triggered a Mode II ejection (Tab H-4). A Mode II ejection trajectory simulation predicts approximately 800 feet AGL is needed for a successful Mode II ejection. The estimated first seat motion is at 744 feet AGL which is predicted to be marginal -- approximately 50 feet short for full parachute inflation. The second seat motion is estimated to be at 586 feet AGL which was unsuccessful, with virtually no parachute inflation at the time of impact (Tab H-13).

Variation in parachute inflation times can shorten or lengthen the recovery by up to approximately 100 ft (Tab H-13). This accounts for why the observer pilot survived the marginal ejection (Tab H-13). However, the forward seat was well out of the ejection envelope (Tab H-14). The mishap pilot's parachute fired at approximately the same time as ground impact and was found unblossomed (not inflated) (Tab H-14). The seat was designed to push the pilot away from the seat, and this separation occurred at approximately the same time the seat came to rest (Tab H-14). For both mishap pilots to have survived the ejection, the aft seat first motion would have had to occur 0.6 seconds earlier at 978 feet AGL followed by the forward seat 0.4 seconds later at 822 feet AGL (Tab H-14).

All egress system inspections were current and all survival equipment used was effective. Only the survival radio and water were used by the observer pilot (Tab V-20).

g. Search and Rescue.

The initial request for search and rescue forces was passed by Flanker 1 to the ground controller at approximately 1819Z, one minute after ejection (Tab N-8). At 1824:06Z, the observer pilot transmitted a Mayday call on UHF Guard that was received by Flanker 2 (Tab N-11). Flanker 2 was then able to communicate with the observer pilot to determine the status of the observer pilot and the mishap pilot (Tab N-11). As this communication was taking place, the Nellis AFB Supervisor of Flying and Nellis AFB Air Boss were notified of the situation and began to monitor and coordinate the search and rescue operation (Tab V-129). The first responder on scene was a Red Flag ground crew member who was located a half mile from the crash site (Tab V-135 thru V-136). He traveled to the site via pick-up truck after seeing the smoke and fire (Tab V-135). Several minutes later a medical crew, associated with Red Flag 08-3 and working in the vicinity of the crash site, arrived via ground vehicle and provided treatment to the observer pilot (Tab V-136). They also located the mishap pilot and determined he was deceased (Tab V-136). The observer pilot was placed on a backboard and remained there until the search and rescue helicopter arrived at 1911Z (Tab EE-2). Fire response vehicles from Tonopah Fire and Rescue arrived fourth and put out the remaining fire (Tab V-137). At 1929Z the observer pilot was transported by the search and rescue helicopter to the Mike O' Callaghan Federal Hospital, Nellis AFB (Tab V-21, EE-3). Upon arrival he was treated for minor injuries and remained in the hospital overnight for observation (Tab V-21). Total elapsed time from the request for search and rescue assets to the arrival of the helicopter on-scene was approximately 52 minutes.

f. Recovery of Remains.

The mishap pilot's remains were transported by helicopter to Mike O' Callaghan Federal Hospital, Nellis AFB several hours after the mishap. An autopsy was performed the next day. Mortuary affairs were handled by the 99th Medical Group, Nellis AFB (Tab R-49, X-2).

5. MAINTENANCE

a. Forms Documentation.

Each Air Force aircraft has a dedicated set of both written and electronic maintenance records used to document all flight and maintenance activities. The written Air Force Technical Order (AFTO) 781 series of forms collectively provide maintenance, inspections, servicing, configuration, status, and flight records for all Air Force aircraft. When AFTO 781 forms are removed from the aircraft's active forms binder, they are kept in a jacket file along with all other aircraft historical data. A thorough review of the AFTO 781 forms and jacket file for the mishap aircraft from 90 days preceding the mishap revealed no evidence of mechanical, structural, or electrical failure. The active AFTO 781 forms for the day of the mishap indicated the mishap aircraft was inspected and prepared for the flight in accordance with applicable technical orders (Tab D-4 thru D-7).

b. Inspections.

The aircraft was current for phase inspection. The mishap aircraft's last major inspection was a phase inspection (hourly post flight #2), accomplished at 5,279.3 flight hours and completed on 11 January 2008. The F-15 requires a phase inspection every 200 flight hours. The phase inspection is a series of three inspections. The total flight hours determine which inspection will be accomplished. The inspection is completed by a phase inspection team, which is composed of crew chiefs and avionic/flight control specialists. Phases consist of removing panels and inspecting aircraft systems for correct operation as well as checking flight control surfaces for proper rigging (ensuring control surfaces are correctly aligned) and to ensure water is not trapped in the flight control surface through non-destructive inspection (NDI) testing. The mishap aircraft had a total of 5,450.8 flight hours with 28.5 flight hours remaining on the current phase inspection (Tab D-3 thru D-4). The next phase inspection (hourly post flight #1) was scheduled at 5479.3 flight hours (Tab D-15).

On 29 July 2008 2100L, the mishap aircraft's last minor inspection, basic post-flight/pre-flight (BPO/PR), was completed. The inspection did not highlight any outstanding issues with the mishap aircraft (Tab D-5 thru D-22). The BPO/PR is completed by the crew chief after the last sortie of the day; it entails a visual inspection of the external airframe structure to include the flight controls, the canopy and ensures proper servicing of fluid levels. In accordance with Technical Order 00-20-1, a BPO/PR is valid for 72 hours and was valid at the time of the mishap.

The mishap aircraft had 9 non-mission related equipment Time Compliance Technical Orders (TCTOs) identified on the AFTO Form 781 K as pending but not overdue; none were a contributing cause to the mishap flight. There were three open delayed discrepancies identified on the AFTO Form 781 K (Tab D-17 thru D-18). These were not a contributing cause to the mishap flight.

The Integrated Maintenance Data System (IMDS), previously known as (CAMS), is the electronic system used for the maintenance management and trend analysis. IMDS data for the mishap aircraft from 90 days preceding the 30 July 08 mishap was reviewed. No overdue inspections, time-change items, or TCTOs were found. IMDS data verified that no negative maintenance trends existed.

c. Maintenance Procedures.

The 65th Aircraft Maintenance Unit (AMU) maintenance procedures were conducted in accordance with Air Force instructions, procedures, and directives, and were not a contributing factor to this mishap.

d. Maintenance Personnel and Supervision:

On 29 July 2008, dedicated/assistant crew chiefs performed the current preflight inspection and servicing on the mishap aircraft (Tab D-6 thru D-11). A weapons team also verified the proper installation of munitions prior to flight, and the Production Superintendent released the aircraft for flight (Tab D-6).

A thorough review of the Air Force Form 623 (Individual Training Record), Air Force Form 797 (Job Qualification Standard Continuation), Integrated Maintenance Data System (IMDS) Special Certification Roster, and all associated maintenance forms was accomplished. Records indicate maintenance personnel assigned to maintain the mishap aircraft were properly trained and had the necessary skill level and qualifications to perform their assigned duties. Data retrieved from Integrated Maintenance Data System revealed unit ancillary training was effectively utilized, and no overdue training tasks were identified.

e. Fuel, Hydraulic and Oil Inspection Analysis.

Maintenance guidance requires the crew chief take engine oil samples following the first flight of the day. Engine oil samples were taken from both engines of the mishap aircraft, the day prior (29 July 08) to the mishap. Results for the engine oil sample taken the day prior reported as acceptable for continued service (Tab D-3). Due to the nature of the impact, no engine oil samples were obtained for testing from the crash site. Oil analysis records from 18 Apr 08 through 29 Jul 08 indicated no trends or indications of excessive engine component wear on either engine (Tab U-2 thru U-3).

After this mishap, the aerospace ground equipment, was initially impounded and subsequently returned to the 57th Aerospace Ground Equipment flight by the Safety Investigation Board

(SIB). Post mishap fluid samples were taken from the oil servicing carts and test results were in a serviceable range (Tab U-4 thru U-5). Fuel samples were also taken from the KC-135 refueling aircraft. These samples were analyzed at Tinker AFB, Oklahoma and met specification requirements (Tab O-5 thru O-6). The SIB did not require samples to be taken from the hydraulic servicing carts since these carts were not used within 48 hour prior to the mishap.

f. Unscheduled Maintenance.

A historical review of Integrated Maintenance Data System and the aircraft forms jacket file from 01 May 08 to 30 July 08 was conducted. All of the following unscheduled maintenance events in this time frame were resolved properly. Below is a list of significant unscheduled maintenance that occurred within the mishap month. None were considered relevant to the mishap.

The Assistant Dedicated Crew Chief identified an oil leak on the #1 engine the day prior to the mishap while completing the Basic Post-Flight Inspection. The leak was isolated to an engine breather valve and was fixed prior to the mishap (Tab U-7 thru U-8).

On 28 July 2008, the mishap aircraft had a #1 engine "no start" condition due to a faulty Jet Fuel Starter Oil Pump Start Cut-Out "50%" Switch. Removal and replacement of this component resolved the start malfunction (Tab U-6).

On 15 July 2008, the mishap aircraft had an In-Flight Emergency for a landing gear slow to lock down prior to landing. The maintenance crew trouble shot the system and found a defective left main landing gear wiring harness which was resolved prior to the mishap (Tab U-9).

On 7 July 2008, the mishap aircraft was impounded for two screws that were identified as missing off the Heads Up Display unit. Impoundments isolate and control access to an aircraft and maintenance records to allow for an intensified investigation to be completed. After an extensive search with multiple personnel, in accordance with the impoundment data checklist, it was determined that the two screws were not accidentally left in the cockpit (Tab U-10).

All maintenance actions were completed in accordance with the proper Technical Data.

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

a. Condition of Systems

A majority of the mishap aircraft was destroyed due to the ground impact and the ensuing fire. All of the wreckage was confined to a small area except for the canopy. The main wreckage

(consisting of both wings, pylons, main landing gear, engines, and aft fuselage with horizontal and vertical stabilizers attached) suffered substantial fire damage at the impact location (Tab J-Part 1-19). The electrical systems and instrumentation were completely destroyed by the fire

and extreme heat (Tab H-17). All of the mechanical systems required for flight appear to have been operating normally prior to the impact (Tab J-Part 1-31).

Some minor aircraft anomalies were noted in the findings below; however, none of these were considered pertinent to the mishap aircraft. The post-mishap analysis and testing of the mishap aircraft components did not reveal any critical internal damage that could have contributed to the mishap (Tab J-Part 1-19 thru J-Part 1-31).

b. Testing

The post-mishap analysis of the aircraft components did not reveal any critical internal/external damage that could have contributed to the mishap (Tab J-Part 1-31).

1. Flight Control Surface Actuators

Boeing's Flight Control Analysis Failure Lab examined the actuators for correct installation, hardware and to verify the actuators were operating correctly externally and internally. The inspection revealed no abnormalities (Tab J-Part 1-19 thru J-Part 1-31).

Right Horizontal Stabilator Actuator

Prior mishaps have revealed that a hard over right stabilator will cause a departure from controlled flight resembling this mishap. The investigation included an extensive inspection of the longitudinal flight control mechanical system to examine the possibility of the stabilator anomaly. The review consisted of a detailed inspection from the mixer assembly through the bell cranks, torque tubes, control rods, and flight control cables, and back to the stabilator actuator. A malfunction of any of these components could have resulted in the stabilator causing the departure; however, engineers confirmed all components and hardware were intact and working properly prior to the mishap (Tab J-Part 1-22, Tab J-Part 2-5).

The external mechanical linkages were damaged in various locations, but all damage appeared to be due to impact (Tab J-Part 1-22). The mechanical inputs were all found to be in the neutral position at impact (Tab J-Part 1-31). The spring-loaded mechanical detent lever was still functional (Tab J-Part 2-23). The spring loaded lever allows the stabilator to return to the neutral position if a mechanical failure occurs. Upon return to the neutral position, the Control Augmentation System (CAS) could be reset and CAS would operate the actuator electronically.

The mechanical input to the manifold appeared to be positioned normally. The piston shaft was extended 3.08 inches which corresponds to the 0.93 degrees nose up (Neutral Position) (Tab J-Part 2-22). The power cylinder was removed from the manifold, and the piston was then removed from the cylinder, where witness marks on the aft cylinder were located 2.80 inches from the inner cylinder aft face (Tab J-Part 2-23). The witness marks prove the stabilator was in the neutral position at impact. Damaged during ground impact, the center dam static seal had a partially split flange on the aft o-ring groove of the aft cylinder. Additionally, the backup ring appeared to be rolled due to impact. The left stabilator actuator also had similar impact damage: the flanges were rolled, not completely cracked and several seals were damaged. All damage

was determined to be due to the impact which caused a hydraulic fluid overload and in turn damaged the seals (Tab J-Part 2-24).

A further review of the internal mechanics of the actuator was conducted by the Boeing Failure Analysis Lab and revealed that all components were in proper working order at the time of the mishap (Tab DD-2 thru DD-15).

Left Horizontal Stabilator Actuator

Due to the impact, external mechanisms of the actuator were damaged in various locations (Tab J-Part 2-17). The piston shaft was consistent with neutral position. The power cylinder was disassembled and witness marks (markings left which indicate position at impact) revealed that the actuator was in the neutral position at impact (Tab J-Part 2-19).

Left Aileron Actuator

The left aileron actuator had sustained very little damage during the impact. The piston shaft was extended and the mechanical input moved properly and was not a factor in the mishap (Tab J-Part 2-25).

Right Aileron Actuator

The right aileron actuator had minimal damage; its gray color was due to the post-impact fire (Tab J-Part 2-27). The piston shaft was extended, and the mechanical input was jammed due to the crash (Tab J-Part 2-28). All internal mechanisms were intact and appeared to be working normally at the time of the mishap (Tab J-Part 1-31, Tab J-Part 2-5). No discernable witness marks were found.

Left Rudder Actuator

The left rudder actuator was inspected prior to removal from the airframe. Inspections discovered that the actuator was installed properly, and all installation hardware was intact (Tab J-Part 1-20). No internal imperfections were revealed that contributed to the mishap (Tab J-Part 1-31, Tab J-Part 2-5). No impact witness marks (markings left which indicate position at impact) could be found. However, due to external fire damage the rotary and stationary vane seals all sustained melting damage. The melt marks indicate the rudder actuator was in the neutral position when the melting occurred. Since the rudder actuator was in the neutral position at the time of impact it did not contribute to the mishap (Tab J-Part 1-31)

Right Rudder Actuator

The right rudder actuator was inspected prior to removal from the airframe. Inspections discovered the actuator was installed properly and all installation hardware was intact. Internally no imperfections were revealed that contributed to the mishap (Tab J-Part 1-31, Tab J-Part 2-5). No impact witness marks could be found (Tab J-Part 2-15). The right rudder actuator was at the 16 degree trailing edge left position; however, this was due to impact (Tab J-Part 2-12). It was

not possible to determine the exact position at the time of impact since there were no witness marks on the rotary or stationary van seals (Tab J-Part 2-14). However, the neutral position may be assumed, since all hardware was intact.

Left Flap Actuator

The left flap actuator was gray in color and had minor heat damage. The piston rod was severely bent due to impact damage; therefore, it was not possible to get an accurate measurement. Disassembly of the actuator was not possible since the actuator was in the fully retracted and locked position (expected) and could not be hydraulically extended. An X-ray of the actuator was taken and revealed no internal abnormalities (Tab J-Part 2-29).

Right Flap Actuator

The right flap actuator was gray in color and had sustained some heat damage and melting. There was no indication that the actuator contributed to the mishap (Tab J-Part 2-30 thru J-Part 2-31).

2. Flight Control Stabilator Cable

There are four longitudinal flight control cables (stabilator cables) in the F-15, one upper and one lower on both the left and right sides. Due to the nature of the mishap Warner Robins Failure Analysis Lab was only able to analyze sections of the right upper and lower cables. Since the right side flight controls were of particular interest, they were closely inspected. Warner Robins' analysis revealed that both cables on the right side were intact prior to the impact. The left side cables were destroyed by the fire (Tab J-Part 1-27, Tab J-Part 2 Analysis Stabilator Cable, pages 1-10). The right flight control stabilator cable was working normally at impact.

3. Radome

The radome is a critical structural element determining the flight characteristics of the F-15. Located at the nose of the aircraft, the radome's first 8-12 inches are the most crucial portion and cannot have surface abnormalities. The radome is inspected during the aircrew's pre-flight inspection and post-flight inspections are conducted by the crew chiefs after every flight. Radome anomalies can exist without being detected by the naked eye. The only way to detect certain radome defects is by laser imaging, which is conducted randomly at the time of production for quality assurance and is not conducted on a routine basis (Tab J Part 1-43 thru 44) This inspection can detect structural imperfections that otherwise would be undetected by daily visual inspections. The mishap aircraft's radome was damaged by the impact and ensuing fire, thus examination was not possible. A review of the 90-day history of the mishap aircraft's maintenance forms and Integrated Maintenance Data System inputs disclosed no maintenance discrepancies related to the radome.

4. Rudder Control Breakout Assembly

No defects were noted to the rudder control breakout assembly (Tab J-Part 1-26). See attached failure analysis of F-15 rudder control breakout assembly and aileron idler arm assembly (Tab J- Part 2).

5. Engines

The Fighter Propulsion Division, Oklahoma City Air Logistics Center, Tinker AFB, Oklahoma, provided an analysis of the F100-PW-220 engines, serial numbers; PW0E711824 and PW0E680777 (Tab J-Part 1-12 thru J-Part 1-18). Both engines were operating at a high power setting at the time of the ground impact. Both exhaust nozzles were at 5-7% open, which is consistent with Military power operation, combined with the CENC Air Valve and Segment Sequencing Valve position on both engines establishes that both engines were at Military power, transitioning into augmentation (afterburner) at aircraft impact (Tab J-Part 1-18). The engines were destroyed due to ground impact, not due to any component failure, and were not a contributing factor to the mishap (Tab J-Part 1-11 thru J-Part1-16).

Aircraft Systems Not Tested

The following aircraft systems were not tested due to severe damage that occurred in the mishap aircraft impact:

- Pitch and Roll Channel Assembly (PRCA)
- Aileron Rudder Interconnect (ARI)
- Left Side Flight Control Cables
- Fuel System
- Hydraulic Control System
- Electrical System
- Environmental Control System
- Warning and Caution Lights
- Instruments
- Landing Gear

After examination of the evidence available to the Accident Investigation Board, it was determined that the above listed non-tested systems were not a contributing cause to the mishap.

Simulator Testing

Simulator testing was conducted in the Boeing Simulator Facility, St. Louis, Missouri on 11 and 12 September 2008 with Boeing subject matter experts. Parameters for testing were derived from Nellis Air Combat Training System (NACTS) data recovered from the mishap aircraft. The NACTS data provided an accurate and precise record of the mishap aircraft parameters throughout the majority of the mishap. The only portion of the NACTS data that is questionable is the angle-of-attack (AOA) as the spin progresses. AOA is computed by the NACTS pod by

using its own internal Inertial Navigation System (INS). Accurate wind estimates are required for the INS to accurately compute AOA. Accurate wind estimates can only be achieved in straight and level flight so, as the aircraft maneuvers, the pod holds the wind estimates constant until they can be updated again in straight and level flight. Because of this, the AOA data during the initial departure and spin entry is accurate. However, as the spin progresses the wind data being used to compute AOA becomes less accurate resulting in unreliable AOA data points (Tab CC-59).

The simulator modeling assumed entry parameters in accordance with the NACTS data. They also assumed approximately a five second pilot reaction time delay before spin recovery controls were applied due to rapid onset rate and initial high "eyeballs out" forces as verified by the observer pilot (Tab V-13). After the delay, spin recovery controls were applied in accordance with the Spin Recovery Display (SRD) and were held until RECOVER was displayed. RECOVER replaces SPIN RECOVERY on the SRD when the aircraft detects less than 20 degrees per second yaw rate (Tab BB-6, BB-7). Once this occurs, the SRD commands equal throttles and the stick position arrow is removed (Tab BB-6, BB-7). During the recovery the throttles were advanced to maximum power (afterburner) and a recovery was attempted while trying to maintain less than 30 cockpit units (CPU) AOA.

Multiple scenarios were flown simulating various asymmetries due to fuel imbalance, pilot flight control inputs, mechanical failures of flight control surfaces and radome imperfections (Tab CC-2 thru CC-4). This process allowed a large number of possibilities to be narrowed to two probabilities. Scenarios that did not meet the parameters or were deemed unlikely due to reasoned improbability, based on redundancies of the F-15 flight control systems, were eliminated. The following two mishap scenarios resulted:

Scenario 1: The mishap aircraft right horizontal stabilator experienced a failure resulting in a trailing edge up condition of at least 25 degrees.

- Simulation verified that this malfunction, if it occurred as the MA approached 60 degrees nose low, would result in a spin profile that closely matches the mishap NACTS data from initial departure through spin recovery (Tab Tab M-7, CC-2, CC-49 thru CC-53).

- This was the only scenario that could be simulated that matched the instantaneous and violent nature of the departure giving no indication of pending departure prior to it occurring (Tab Tab M-7, CC-2, CC-51).

- This malfunction caused the aircraft to depart with the aircraft below 30 CPU AOA when the malfunction occurred.

- This malfunction would give indications that the aircraft was recovering from the spin even though the aircraft was actually unrecoverable regardless of pilot action due to the flight control failure.

- However, indications of a spin recovery would generally occur prior to that experienced in the mishap. In order to match the delayed spin recovery experienced by the mishap crew a fuel imbalance of 500 – 750 pounds was also necessary (Tab CC-2, CC-49 thru CC-53).

- Analysis of the witness marks found on the right stabilator actuator shows that it was in the neutral position at ground impact (Tab J-Part2-24).

- Finally, all analysis done on recovered aircraft flight control components that interact with the right stabilator revealed no failures and all components were assessed to be operating normally at the time of impact (Tab J-Part1-31, J-Part 2-5).

Scenario 2: The mishap aircraft had a fuel imbalance of at least 750 lbs (7500 ft-lbs) right side heavy and had an undetected radome imperfection.

- The design of the F-15C/D external fuel system leaves it susceptible to producing external wing tank fuel imbalances that can leave the aircraft extremely susceptible to departures. The F-15C/D uses differential pressure to transfer fuel from the external wing fuel tanks to the internal wing fuel tanks (Tab BB-3). 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 an eventual fuel imbalance (Tab BB-3). Air-to-air refueling requires depressurization of the external tanks. Once refueling is complete the tanks are then pressurized. It is not uncommon for the F-15C/D to experience external fuel transfer problems after air-to-air refueling as a result of this cycle.

- AFI 11-2F-15V3, F-15 Operations Procedures states “if wingmen are within 500 lbs of the flight lead, a ‘same’ call may be used at the discretion of the OG/CC” and, when more than one external tank is carried, add a “tanks feeding” call to the normal Ops Check reply. No additional guidance could be found at Wing, Group or Squadron level. Interviews of other 65th Aggressor Squadron pilots indicated varying techniques for when to call a fuel imbalance. Most indicated they would call the imbalance when it met or exceeded 500 lbs (5,000 ft-lbs) of asymmetry (Tabs R-4, V-72 thru V-73). It is reasonable to conclude that a fuel imbalance of less than 500 lbs could go unreported resulting in a “same” call during a fuel check.

- With a <u>balanced</u> fuel load and configured as it was at the time of the mishap, the mishap aircraft would have been approximately 450 foot pounds (ft-lbs) left side heavy (Tab CC-63).

- The TO 1F-15A-1 describes the F-15C/D as extremely susceptible to departure with a 7,000 ft-lbs or greater imbalance above 30 CPU AOA. Extremely susceptible means that departure from controlled flight/spin will generally occur with the normal application of pitch control alone or with small roll and yaw control inputs. This can occur almost instantly (Tab BB-22, CC-63).

- Despite being extremely susceptible to departure, the TO 1F-15A-1 also describes the F-15C/D as spin resistant given the above imbalance. Resistant means that departure/spin

will only occur with a large and reasonably sustained (more than 3 seconds) misapplication of pitch, roll or yaw controls (Tab BB-22).

- In order to achieve at least 7,000 ft-lbs of asymmetry right side heavy, the mishap aircraft would have required a minimum of 750 pounds more fuel in the right external tank than in the left (Tab CC-63). A fuel imbalance alone is not enough to cause both the spin and delayed spin recovery experienced by the mishap crew. This was verified in the simulator. Although there was variation in recovery time based on imbalance, in all cases the aircraft recovered prior to descending below 12,000 feet MSL (Tab CC-3 thru CC-4).

- Radome imperfections in the F-15C/D can induce strong yawing moments at extreme AOA, generally above 65 to 70 CPU AOA. However, slight imperfections in the forward 8 – 10 inches of the radome can yield these strong yawing moments as low as 50 – 60 CPU AOA. The magnitude of this yawing moment at high AOA can be twice the moment generated by full rudder deflection at low AOA (Tab BB-26).

- At the start of the departure, the mishap aircraft did not achieve enough AOA for the radome imperfection to be a factor (Tab M-7). The radome imperfection, therefore, could not have caused the departure. However, as the departure progressed and the AOA increased, a radome imperfection could have caused an additive yawing effect, decreasing spin resistance. It would also contribute to a delayed recovery time. This was verified and repeatable in the simulator. Coupling the radome imperfection with the fuel imbalance yielded delayed recoveries closely matching that experienced during the mishap. (Tab CC-3 thru CC-4, CC-44 thru CC-48)

- There were several characteristics of the departure and spin that could not be matched in the simulator with 2,000 pounds or less of fuel imbalance and/or radome imperfection:

  (i) The instantaneous/violent nature of the departure could not be matched. Without exception, the simulator would not depart unless the aircraft was held above 30 CPU AOA for several seconds. As a result, the simulator gave multiple indications of a pending departure (AOA tones, yawing motion and finally 3 – 4 yaw warning tones before spin entry) that would have been very apparent to the mishap pilot. (Tab CC-3 thru CC-4, CC-39 thru CC-48)

  (ii) The peak yaw rate of 160 degrees per second seen in the NACTS data could not be achieved unless at least a 2,000 pound fuel imbalance was present (Tab M-7). At imbalances below 2,000 pounds the max yaw rate achieved in the simulator was approximately 130 degrees per second (Tab CC-3 thru CC-4, CC-39 thru CC-48).

- The mishap aircraft time of departure from controlled flight can only be determined within .4 seconds given the actual data transmission rate of the NACTS pod (Tab M-7). Within this time period, the CPU AOA is 30 – 34 (Tab M-7). The TO 1F-15A-1 keys warnings to 30 CPU AOA. With less than half a second spent above 30 CPU prior to departure, the pilot would not have had warnings consistent with those listed in the TO 1-F-15A-1.

Two other factors considered were also worth noting. First, the MA was configured with an Advanced Capabilities (ACaP) pod on station 3 (left forward fuselage) (Tab D-4). The 65th Aggressor Squadron (AGRS) is currently the only F-15C/D squadron employing the ACaP pod. Although some 65th AGRS pilot testimony indicates the F-15C/D flies slightly different at high AOA with the ACaP on station 3, Air Force SEEK EAGLE flight testing has shown that the ACaP pod does not adversely affect the handling qualities of the F-15C/D across the flight regimes (Tab R-20 thru R-21, Tab CC-54 thru CC-56). In addition, the MA was flown the day prior to the mishap in the exact same configuration and the pilot, when interviewed, stated he did not note any abnormal flight characteristics associated with the mishap aircraft and/or the ACaP pod in any flight regime (low or high AOA) (Tab V-34 thru V-35). Analysis of the NACTS data from this sortie supported the pilot's testimony. There is no indication that the ACaP pod was a factor in this mishap.

Finally, several F-15D aircraft have been reported to experience a rapid onset of left yaw/roll at approximately 32 – 34 CPU AOA when configured with two external tanks. This problem has been tested to occur when airspeed is approximately 250 – 350 knots (higher airspeed yields more violent motion) and the left yaw/roll is apparent during both left and right bank turns. Testing has shown that not every F-15D exhibits this trait, but those that do are very repeatable as long as the pull does not quickly pass through 32 – 34 CPU AOA. There is currently no explanation for the cause of this anomaly. The mishap aircraft does satisfy the requirements for this phenomenon to occur. The aircraft had not displayed this tendency in previous flights. However, recent testing conducted at Robins AFB, GA on F-15D tail number 78-0563, an aircraft that had no documented history of this anomaly, showed that the aircraft exhibited the abrupt left yaw/roll characteristic whenever it was flown into the 32 – 34 CPU region. The abrupt left yaw/roll associated with this phenomenon is very similar to that the NACTS data indicates was experienced by the mishap crew. This type of rapid left yaw/roll could provide the spark necessary to cause a departure and subsequent spin if coupled with a lateral asymmetry. Unfortunately, little is currently known about this phenomenon. As of now, both Air Force and Boeing engineers state it is unexplainable. The phenomenon has not yet been modeled in the simulator and therefore could not be replicated (Tab CC-60 thru CC-62).

The F-15C/D was designed to prevent a single flight control failure from having catastrophic effects for both reliability and combat survivability. That is not to say that a single failure could not be catastrophic, but instead to say that a single failure yielding catastrophic results is highly unlikely. The mishap aircraft's departure is the result of a string of circumstances where the resulting aerodynamic forces on the aircraft exceeded the stability of the jet. (Tab J-Part 1-45)

7. WEATHER

a. Forecast Weather.

The forecast weather at the NTTR was for clear skies and 7 miles visibility with no significant weather expected. The winds were from the southwest gusting at 10 to 15 knots with and no thunderstorms, turbulence or icing (Tab F-3).

b. Observed Weather.

Observed weather at the NTTR was clear skies, unrestricted visibility with winds from the south at 10 mph gusting to 16 mph, temperature 30C, and altimeter 30.15 (Tab F-4).

c. Space Environment.

Not applicable.

d. Conclusions.

The mission was flown in compliance with weather requirements (AFI 11-202, Vol. 3, *General Flight Rules*, dated 5 April 2006, and AFI 11-214, *Air Operations Rules and Procedures*, dated 22 December 2005).

8. CREW QUALIFICATIONS

a. Mishap Pilot

The MP was a fully qualified Instructor in F-15C and F-15D aircraft (F-15C/D) (Tab AA-2). All necessary flight currencies were up-to-date and all required training for the planned mission was current in-accordance with AFI 11-2F-15, Volume 1, *Flying Operations, F-15 Aircrew Training*, dated 18 January 2007 (Tab T-2 thru T-8). On 23 June 2008, the MP performed his most recent instrument qualification in the F-15C/D and on 21 July 2008 completed his mission qualification (Tab G-10 thru G-13). He rated "Qualified, No Discrepancies" and received a "Commendable" for mission planning on his mission qualification check ride (Tab G-10 thru G-13).

The MP was a Command Pilot with 4,256.9 hours of military flying time. Of this total, the MP had 1,867.9 hours of primary F-15B/C/D time, with 697.2 hours as an F-15C/D Instructor Pilot, and 47.9 hours as an F-15C/D Evaluator Pilot (Tab G-5 thru G-7). Additionally, he was an instructor pilot in both the T-38A and Royal Air Force Tornado F-3. The MP was an experienced combat pilot, logging 256 combat hours in the F-15C and Tornado F-3 during OPERATION NORTHERN WATCH, OPERATION SOUTHERN WATCH, and OPERATION IRAQI FREEDOM (Tab G-5 thru G-7). He was a highly decorated pilot, acquiring the following honors, among others, during his career: The Meritorious Service Medal with 2 Oak Leaf Clusters, the Air Medal with 3 Oak Leaf Clusters, the Aerial Achievement Medal, the Air Force Commendation Medal with Oak Leaf Cluster, the Air Force Achievement Medal, and the Air Force Outstanding Unit Award with Valor (JJ-2). Additionally, on 4 August 2008, he was posthumously awarded the Meritorious Service Medal (Third Oak Leaf Cluster).

The MP's recent flights prior to the mishap sortie were (Tab G-4):

Lookback	Hours	Sorties
30 days	9.8	8
60 days	14.1	12
90 days	43.6	21

b. Observer Pilot

The OP was an experienced Royal Air Force (RAF) exchange pilot with 1,633.3 hours of military flying time (Tab T-9). He is a fully qualified RAF Instructor Pilot with 1,214.6 hours of total F-3 Tornado time and 565 hours as an F-3 instructor (Tab T-15). Prior to the mishap, the OP had completed the F-16 Follow-On Training Unit (FTU) transition course at Luke AFB, where he logged 33.3 hours of primary F-16 flight time (Tab T-9 thru T-13). He had two sorties in a 64th Aggressor Squadron F-16, logging 2 hours in the Nevada Test and Training Range for familiarization and Basic Fighter Maneuvers training (Tab T-14, V-4 thru V-5). Additionally, the OP flew the day prior, 29 July 08, in the backseat of the mishap aircraft for Red Flag orientation and observation (Tab V-4). All necessary flight currencies and F-15 orientation training were up-to-date (Tab G-14 thru G-15). The OP's recent F-16 flights prior to the mishap sortie were (Tab T-9 thru T-15):

Lookback	Hours	Sorties
30 days	6.9	6
60 days	23.7	22
90 days	32.6	30

9. MEDICAL

a. Qualifications.

At the time of the mishap, the mishap pilot (MP) and observer pilot (OP) were both medically qualified for flight duty. The MP's last flight physical was accomplished on 29 November 2007, and his medical flight clearance (AF Form 1042) was current and complete (Tab X-2). On 14 July 2008, the OP received his initial medical flight clearance for Nellis AFB (Tab X-3).

b. Health.

There is no indication that either the MP's or OP's health contributed to the mishap. As a result of the ejection, the OP suffered a lumbosacral strain (Tab X-2).

c. Toxicology/Pathology.

Toxicological examination was conducted by the Armed Forces institute of Pathology. The toxicology tests were normal (negative). The carbon monoxide level was normal for the observer pilot and untestable for the mishap pilot (Tab X-2, X-4). The mishap pilot died from catastrophic trauma from the ground impact (Tab X-2).

d. Lifestyle.

There is no evidence that unusual habits, behavior, or stress on the part of the mishap pilot or observer pilot contributed to the accident (Tab R-8, R-23 thru R-44, V-22 thru V-23).

e. Crew Rest and Crew Duty Time.

Air Force Instructions require pilots have proper "crew rest," prior to performing in-flight duties, which is defined as a minimum of a 12-hour non-duty period before the designated flight duty period. Its purpose is to ensure the aircrew member is adequately rest before performing flight or flight-related duties and has had the opportunity for at least eight hours of uninterrupted sleep. According to witnesses, the MP and OP met the requirements for crew rest as outlined in by AFI 11-202, Vol. 3, *General Flight Rules*, dated 5 April 2006, para. 9.7.1. (Tab G-17, V-22 thru V-23).

10. OPERATIONS AND SUPERVISION

a. Operations.

The 65th Aggressor Squadron was a highly experienced squadron with a total of 17 pilots, 16 of whom are "experienced" aviators (having greater than 500 hours flight time in the F-15C/D) (Tab AA-2). At the time of the mishap, the operations tempo of the 65th Aggressor Squadron was normal and its members were participating in Red Flag 08-3 in their role as aggressors (Tab R-14). Both the 64th and 65th Aggressor Squadrons recently returned from exercises MAPLE FLAG and NORTHERN EDGE respectively, and proficiency was high (Tab R-19, R-37). There is no indication operations tempo contributed to the mishap.

b. Supervision.

Supervision at the squadron, group, and wing level was appropriate and engaged. The 57th Wing, Nellis AFB released a Flight Crew Information File (FCIF) six days prior to the mishap to refocus aircrew on departure prevention and recoveries in response to recent F-16 incidents (Tab AA-3). The FCIF does not address out-of-control ejection altitudes, but squadron supervision did emphasize minimum ejection altitudes in the event of an out-of-control situation (Tab R-33, V-50, V-68, V-77, V-92, V-96, AA-5). Additionally, several witnesses testified the mishap pilot, in his role as squadron commander, personally briefed his pilots on this FCIF and its importance (Tab 68, V-92, V-124). Even though he was deployed, the 57 ATG/CC remained fully engaged with both the 64th and 65th Squadron Commanders. He contacted both commanders concerning the recent F-16 departures in the 64th AGRS and the implementation of the FCIF. He had no concerns about the 65th AGRS supervision during this time (Tab V-126).

The 64th and 65th Aggressor Squadrons use a standard Red Air Commander briefing guide for Red Air coordination briefs (Tab AA-4). The briefing guide refers to out-of-control ejection altitudes and was used by MIG-1 (Red Air Commander) before the mishap sortie. Although MiG-1 does not specifically remember briefing minimum out-of-control ejection altitudes, FLANKER-2, the instructor of record for FLANKER flight, does remember the topic being covered during Red Air coordination (Tab R-19). Without exception, every pilot member of the flight was aware of the 6,000 feet Above Ground Level (AGL) out-of-control ejection altitude minimum for ACES-II ejection seats, but could not definitely remember a Mean Seal Level (MSL) altitude being discussed (Tab R-12, R-19, V-26, V-50, V-51, V-93, V-125).

The calculated Operational Risk Management level of the mission was "Increased" due to the following factors: at least one flight member had only 5-7 hours of sleep; at least one flight member was in training; at least one member had marginal 30-day look-back (between five and eight sorties over the last 30 days); Red Flag Blue Air was dropping live munitions and accordingly, airspace restrictions were high (Tab G-17). It is important to note both squadrons frequently operate at an "Increased" risk level for Red Flag sorties, are fully aware of the variety of experience levels presented by Blue Air, and utilize a host of in-flight procedures to mitigate the higher risk level (Tab V-42 thru V-50). Risk mitigation efforts for increased operational risk were appropriate, and there is no indication identified increased risk factors contributed to this mishap.

11. HUMAN FACTORS ANALYSIS

The Department of Defense Human Factors Analysis and Classification System includes a list of potential human factors that are contributory to a mishap. All factors within the guide were assessed for relevancy regarding the mishap. The human factors relevant to the 30 July 2008 mishap at the Nevada Test and Training Range are discussed below. Analysis indicates human error is identified as a causal factor in 80 to 90 percent of mishaps. Human factors are, therefore, the greatest mishap hazard (Department of Defense Human Factors Analysis and Classification System, dated 11 Jan 05) (Tab HH-3 thru HH-5)

a. PE 108: Maneuvering Forces - In-Flight

Maneuvering Forces – In-Flight is a factor when acceleration forces of longer than one second cause injury, prevent or interfere with the performance of normal duties (Department of Defense Human Factors Analysis and Classification System, 11 Jan 05) (Tab HH-4).

In-flight maneuvering forces were relevant to this mishap because the MA's aggressive departure entry induced a high negative transversal G-loading on both the MP and OP. The MA experienced a maximum spin rate of 160 degrees per second, inducing an outward "eyeballs out" negative G-loading on the MP (-5.5 G's) and the OP (-4 G's) (Tab CC-9 thru CC-10). The departure entry forced the OP's body forward and prevented upper body movement for nearly five seconds (Tab V-13). After the MA settled into the spin, the OP was able to reposition his body into a proper ejection posture and was able to monitor the recovery procedure (Tab V-13). Communication from the MP during the initial departure sequence (when spin rate and G-loading were highest) indicates the MP was physically able to use flight controls and attempt the F-15C/D spin recovery procedure approximately five seconds after initial departure entry (Tab V-13 thru V-14). Additionally, communication between the MP and OP throughout the remainder of the spin indicates the MP was coherent and functional and was not prevented from executing appropriate anti-spin controls (Tab V-13 thru V-14).

b. AE 204: Necessary Action - Delayed

Necessary Action – Delayed is a factor when an individual selects a course of action but elects to delay execution of the actions and the delay leads to an unsafe (Department of Defense Human Factors Analysis and Classification System, 11 Jan 05) (Tab HH-4).

The MP and OP did not eject at the recommended 6,000 feet Above Ground Level (AGL) out-of-control bailout altitude as recommended by Technical Order 1F-15A-1 (Tab BB-12). Two factors may have caused the MP to delay his decision to eject at the recommended minimum altitude: altimeter lag and apparent aircraft recovery.

1. Altimeter lag. Technical Order 1F-15A-1 states that as the angle of attack increases between 35 and 40 cockpit units (45-50 degrees), the barometric altimeter may provide delayed altitude information, and can read as much as 1,500 feet higher than the aircraft's actual altitude (Tab BB-19). This condition is known as "altimeter lag" and is a well known limitation of the F-15. During the spin, the mishap aircraft's angle-of-attack was well above 45 cockpit units and susceptible to altimeter lag (Tab CC-7, II-2). As the MA passed through the recommended bailout altitude of 11,400 feet MSL (terrain elevation: 5,400 feet MSL) due to altimeter lag, the altimeter may have indicated the MA was as high as 12,900 feet. Given this possibility, as the indicated barometric altitude passed 11,400 feet on the altimeter, the MA may have actually been descending through 9,900 feet MSL, or 4,500 feet above ground level. Although altimeter lag is a concern for extended high angle of attack maneuvering, as in a spin, the lag effect normally corrects 1-2 seconds after angle of attack is reduced below 30 CPU.

2. Apparent aircraft recovery. Between 10,500-9,200 feet MSL (5,100-3,800 feet above the terrain), the MA's spin rate slowed, the nose dropped to approximately 50 degrees nose low and a recovery from the spin was indicated (Tab V-14 thru V-19, II-2). As the MA passed through the minimum out-of-control ejection altitude, the MP may have consciously decided to delay ejection to recover the aircraft (Tab V-13 thru V-14, V-18). The OP, likewise, had mentally calculated an out-of-control ejection altitude of 10,000 feet above sea level based on an assumed terrain altitude of 4,000 ft MSL (Tab V-18). Given the apparent spin recovery and communication between MP and OP, the OP also consciously delayed ejection (Tab V-18). Based on their assessment of their height above ground using the barometric altimeter, and not considering altimeter lag, the MP and OP thought they had sufficient altitude to recover the aircraft (Tab V-15, V-17).

c. 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 (Department of Defense Human Factors Analysis and Classification System, 11 Jan 05) (Tab HH-5).

The mishap crew failed to recognize the minimum above terrain altitude needed for safe ejection (Tab V-16). During the spin and apparent recovery at low altitude, there was a distinct lack of

ground features or cultural development of known size, so they could not quickly judge their distance or altitude based on visual cues (Tab V-26). The cockpit instruments showed pressure altitude at MSL rather than at AGL. The pilot needed to mentally subtract the altitude of the terrain from the barometric altitude displayed in the cockpit to know the actual height above terrain. The altitude of the ground in the area the mishap crew was flying over varied by several thousand feet because of terrain peaks and valleys.

The OP was altitude aware based on altimeter readings, but did not truly appreciate how low the mishap aircraft was until he experienced a sense of ground rush and realized ground collision was imminent (Tab V-19).

d. PC 502: Illusion-Vestibular

Illusion-Vestibular is a factor when stimuli acting on the semicircular ducts or otolith organs of the vestibular apparatus cause the individual to have an erroneous perception of orientation, motion or acceleration leading to degraded performance (Department of Defense Human Factors Analysis and Classification System, 11 Jan 05) (HH-5).

Post-departure, the MA completed 20 revolutions in 75 seconds, descending from 30,000 feet above sea level until ground impact at 5,400 feet above sea level. The initial spin rate rapidly climbed through 160 degrees per second and then settled to 65-90 degrees per second through the majority of the departure (Tab CC-9). The "eyeballs out" G-force on the mishap pilot was approximately -5 Gs at the highest spin rate, but rapidly settled into a -1.5 to -2.0 G range as the spin rate declined (Tab CC-10). Given these conditions, the MP was affected by the constant spin rate, with the potential for spatial disorientation.

It is likely the mishap pilot suffered from some degree of vestibular illusion and nystagmus generated by the sustained left spin. The prolonged spin caused the inner-ear balance mechanism to equalize, which minimized the rotating sensation felt by the mishap crew as the aircraft continued to spin. When the spin finally stopped, the inner-ear fluid would have kept moving due to inertia (Tab HH-2). This condition caused the MP to perceive rotation in the opposite direction, and could have led him to counter this perceived motion by adjusting the flight controls, especially if outside visual references were not used, i.e. the mishap pilot was looking in the cockpit (Tab V-118).

Evidence suggests the following occurred after the pilot began a nose-low recovery passing 9,200 ft mean sea level (3,800 ft above the ground):

As the mishap pilot began his recovery, he increased power and started a smooth 2-G pull to the horizon. The mishap pilot did not execute a straight pull, but banked slightly right (5-10 degrees) momentarily as he recovered the aircraft (Tab II-2). The MP was likely affected by a vestibular illusion and ocular nystagmus upon exiting the spin, but was able to counter the effect using large external visual cues, such as the horizon (Tab HH-2). At some point, the MP selected afterburner and may have attempted to reset the control augmentation system (Tab J-Part1-12, BB-20). Given the position of the control augmentation switches and its difficulty to access with afterburner selected (throttles in the full forward position) the MP could have

focused his attention inside the cockpit. With his attention inside the cockpit and without the aid of external environmental cues (horizon, mountains, etc.), the MP would have experienced a "seat-of-the-pants" right yaw associated with a vestibular illusion. Thus, if the mishap pilot had focused his attention inside the cockpit, spatial distortion could account for the yaw and roll parameters documented during the mishap sortie. The evidence clearly shows the mishap aircraft was in coordinated flight after recovery from the spin until ejection was initiated (Tab CC-5 thru CC-10, CC-59). Further, the MA parameters at the recovery point do not approach the parameters that initiated the departure at altitude nor would they precipitate a departure under normal conditions.

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Primary Operations Directives and Publications.

AFI 11-2F-15, Volume 1, *F-15 Aircrew Training*
AFI 11-2F-15, Volume 3, *F-15 Operations Procedures*
AFI 11-202, Volume 1, *Aircrew Training*
AFI 11-202, Volume 2, *Aircrew Standardization/Evaluation Program*
AFI 11-202, Volume 3, *General Flight Rules*
AFI 11-214, *Air Operations Rules and Procedures*
AFI 11-418, *Operations Supervision, as supplemented*
T.O. 1F-15A-1, *Flight Manual*
T.O. 1F-15A-1CL-1, *Flight Crew Checklist*

b. Maintenance Directives and Publications.

AFI 21-101, *Aerospace Equipment Maintenance Management*
T.O. 1F-15C-2-27JG-40-2, *Flight Control System-Longitudinal Control*
T.O. 1F-15C-2-27JG-20-2, *Flight Control System-Directional Control*
T.O. 1F-15A-6WC-5, *Hourly Post flight/Periodic Inspection Work Cards*

c. Medical Directives and Publications.

AFI 48-123, Vols. 1-3, *Medical Examinations Standards*
Department of Defense Human Factors Analysis and Classification System

d. Known or Suspected Deviations from Directives or Publications.

The mishap pilot momentarily exceeded 30 cockpit units with fuel in the wing external fuel tanks. T.O. 1F-15A-1 prohibits exceeding 30 cockpit units angle of attack with fuel in the wing mounted tanks. The Board President determined this momentary deviation was unintentional. T.O. 1-F15-A-1, Section 5, Page 5-4, Prohibited Maneuvers, Paragraph c. (4) (Tab BB-13).

The mishap crew did not initiate ejection at or above 6,000 feet above ground level 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.

The Board President determined both crew elected to go below their uncontrolled ejection minimums during the spin because they misperceived their altitude above the ground. T.O. 1F-15A-1, Section 3, Page 3-19, Warning (Tab BB-12).

13. NEWS MEDIA INVOLVEMENT

Initial Queries and Reports.

Following the mishap, media interest related to the incident was high. Reporters from local newspapers and television stations in Las Vegas, as well as the Associated Press, the "Air Force Times," various newspapers located near Air Force installations and CNN covered the mishap. On 31 July 2008, now Brigadier General Russell Handy, 57th Wing commander, held a press conference. Media interest has been minimal since the story was first reported. Samples of media coverage are attached at Tab FF-2 thru FF-8.

30 September 2008

ROBERT P. OTTO, Brigadier General, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

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 an aircraft 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 30 July 2008 at 1817 Zulu (1117 local time), aircraft F-15D, serial number 85-0131, departed controlled flight and spun while executing a planned maneuver during exercise Red Flag 08-3. It impacted the ground 20 miles northwest of Rachel, Nevada in an uninhabited area on the Nevada Test and Training Range (NTTR) belonging to the Bureau of Land Management. Both aircrew ejected. The back seat observer pilot sustained minor injuries and was rescued; the front seat pilot hit the ground before his parachute canopy fully deployed and died immediately upon ground impact.

I find by clear and convincing evidence this mishap was caused by a sudden departure from controlled flight during a routine maneuver when the mishap pilot momentarily exceeded the allowable angle of attack. Through extensive simulation, I find each of the following factors substantially contributed to the mishap: (1) an external wing fuel imbalance of at least 750 pounds; (2) F-15D left yaw/roll phenomenon when configured with two external wing tanks; and (3) a radome (nose cone) imperfection. After the mishap pilot recovered the aircraft from the spin, spatial disorientation hampered the dive recovery. I find clear and convincing evidence that at low altitude, this spatial disorientation was also causal to the mishap and ultimately led to the mishap pilot's death.

2. DISCUSSION OF OPINION:

Precise and verified aircraft performance information was used to recreate the flight path and flight characteristics. The Board examined engineering analysis of all the recovered flight control components including the wings, ailerons, flaps, horizontal stabilators, vertical stabilizers, rudders, as well as the air inlet ramps and speedbrake. All were intact and attached to the aircraft when it impacted the ground. All control surfaces appeared to be in a neutral or approximately neutral position.

Discussion with technical advisors, witnesses, and 74 simulator runs provided clear and convincing evidence that only two scenarios matched the mishap profile. The first was a hard over right stabilator (horizontal tail) with the trailing edge up. However, there is substantial physical evidence negating the possibility of a hard over right stabilator since there were no pre-mishap abnormalities with the associated components, and there is incontrovertible evidence the

stabilator was approximately neutral at impact. The second scenario involved a combination of factors that included a fuel imbalance, F-15D left yaw/roll phenomenon, and radome imperfection.

a. Fuel Imbalance

External wing fuel imbalance produces a lateral asymmetry that is a major source of degraded F-15 handling qualities which can precipitate a departure from controlled flight and spin. All simulation runs proved that absent a major flight control failure, a wing fuel imbalance was the only way to induce a spin under the mishap aircraft's flight parameters. At least one of the two external wing tanks had fuel on impact but there was no way to determine the balance of fuel between them. Given the mishap aircraft's configuration, the minimum fuel imbalance to produce a spin was 750 pounds.

As a result of pressure variations between the two respective external wing tanks, the wing tanks may not transfer fuel at the same rate. Further, the mishap crew had just air refueled—a frequent cause of external fuel transfer problems. The mishap pilot was not expected to report a fuel imbalance of up to 500 pounds and the last fuel check occurred twelve minutes prior to the mishap. The observer pilot stated no fuel checks or discussion of fuel were made after that time, and the observer was flying the aircraft during that phase. With the observer pilot flying and the mishap pilot pointing out mission related information, the mishap pilot would have been less likely to check fuel balance than if he were at the controls. Twelve minutes and approximately 2000 pounds of fuel consumption later, the mishap pilot took command of the aircraft controls and immediately began tactical maneuvering without verbalizing a fuel check. With the knowledge that only a fuel imbalance could produce the lateral asymmetry, there is sufficient evidence to conclude a right wing fuel imbalance of at least 750 and possibly as much as 2000 pounds contributed to the spin. This right wing heavy fuel imbalance introduced a yawing moment during the mishap pilot's inverted, wings level pull that, in combination with the F-15D left yaw/roll phenomenon, precipitated a departure.

b. F-15D Left Yaw/Roll Phenomenon

The angle of attack at which the aircraft will depart controlled flight varies with the magnitude of lateral asymmetry (fuel imbalance); regardless of magnitude, departure should not occur below 30 cockpit units angle of attack (AOA). With a 700 to 1,000 pound external wing fuel imbalance, the F-15 is spin resistant which means a departure and subsequent spin would only occur with a large and reasonably sustained (more than 3 seconds) misapplication of flight controls above 30 cockpit units angle of attack. Analyzing the mishap pilot's maneuver entry, even a fuel imbalance of 2000 pounds would have required a reasonably sustained misapplication of flight controls. This was confirmed through multiple simulator runs. Mishap reconstruction and tape review showed a reasonably sustained misapplication did not occur although a momentary deviation above 30 cockpit units did occur.

Close review of the mishap tape showed the aircraft rapidly and violently departed controlled flight after only one-half second in the 30-34 cockpit units regime. Exceeding 30 cockpit units angle of attack is a prohibited maneuver with any fuel in the wing tanks. It is my opinion this

deviation was inadvertent because the mishap pilot was widely regarded as a commander who knew the rules and enforced them. Further, the mishap pilot was 40 miles from the nearest adversary so there was no reason to aggressively execute this routine maneuver. The yaw warning tone sounded immediately (within one-half second) upon reaching the 30-34 cockpit units AOA region. The immediate yaw tone and departure indicates there was not a reasonably sustained misapplication of flight controls. Therefore, I find clear and convincing evidence that the fuel imbalance alone could not have caused the abrupt left yaw and violent departure from controlled flight.

The F-15 System Program Office reports several F-15D aircraft have experienced a rapid onset of a left yaw/roll at approximately 32-34 cockpit units angle of attack when configured with two external tanks in the 250-350 knot regime. While not every F-15D exhibits the trait, those that do are repeatable as long as the pull does not quickly pass through 32-34 cockpit units. This phenomenon is not well documented or tested and the number of confirmed cases is modest. Although there is no history of the mishap aircraft showing this tendency, all other documented cases showed a similar "clean" history and still displayed the phenomenon under the mishap conditions, albeit at the narrower 32-34 unit region. Since this D-model phenomenon resembles the mishap aircraft parameters, it is my opinion the F-15D yaw/roll phenomenon associated with this F-15D configured with two external wing tanks substantially contributed to the initial yaw moment and subsequent spin entry.

c. Radome

The radome (nose cone) was extensively damaged upon impact and could not be analyzed. However, there is substantial documentation that the outer 8-10 inches of the radome must be free of nicks, chips, and imperfections or strong yawing moments can result. The magnitude of this force above 50 cockpit units angle of attack can be twice the force generated by full rudder deflection at low angle of attack. Investigation into an entire wing's F-15 fleet noted that up to one-fourth of the fleet had significant radome imperfections. Investigation showed that radome anomalies can exist without being noticed by the pilot or crew chief. Since the aircraft rarely get to the angle of attack where radome anomalies manifest themselves, the imperfection can go undetected. Simulator testing showed, absent a radome anomaly, the fuel imbalance alone could not produce the sustained spin. Likewise, it is my opinion the fuel imbalance combined with the D-model yaw/roll phenomenon produced the abrupt departure and spin, but does not account for the sustained spin the mishap aircraft experienced. Simulation provided substantial evidence a radome anomaly aggravated the yawing moment in the spin resulting in 20 revolutions prior to recovery. It is my opinion a radome anomaly existed at the time of the mishap which introduced an additional yawing moment once the aircraft reached at or above 50 cockpit units angle of attack, substantially contributing to the spin.

d. Ejection Decision

Observer pilot testimony revealed there was strong Mean Sea Level (MSL) altitude awareness during the spin. The pilot manual recommends ejection if spin recovery is not apparent by 6,000 feet above ground level (AGL), which was 11,398 feet MSL. The observer pilot thought 6,000 feet AGL was equal to 10,000 feet MSL, so he misjudged the terrain elevation by nearly 1,400

feet. The data conclusively shows recovery was not apparent by 6,000 feet AGL. There is clear and convincing evidence that both crew elected to go below their uncontrolled ejection minimums because they misperceived their altitude above the ground. This misperception was causal in the mishap pilot's death.

The mishap aircraft stopped spinning and likely displayed "RECOVER" at 9,200 feet MSL (3,800 feet AGL), 140 knots, 50 degrees nose low. Recovery from this altitude was possible but required quick and decisive action to neutralize all controls, match the throttles with maximum afterburner, reset the CAS (control augmentation system), and let residual yaw and roll motions subside. Data shows the mishap pilot began a normal post-spin recovery and then had seven seconds of coordinated left roll at a time he should have been recovering from the dive. The coordinated profile indicates the airplane was being flown rather than departing from controlled flight. It is my opinion that the sustained left spin induced a vestibular dysfunction so when the aircraft quit spinning left, spatial disorientation left the mishap pilot with a strong misperception the aircraft was yawing right. As he looked down to reset the CAS or his attention was inside the cockpit, he subconsciously countered this perceived right yaw with left aileron which delayed recovery and produced a low altitude, unusual attitude. When the mishap crew initiated ejection they were significantly below the recommended altitude. Therefore, it is my opinion there is clear and convincing evidence to conclude spatial disorientation was causal in the mishap and ultimately led to the mishap pilot's death.

3. CONCLUSIONS

I find clear and convincing evidence this mishap was caused by a sudden departure from controlled flight during a routine maneuver when the mishap pilot momentarily exceeded the allowable angle of attack. Through extensive simulation, I find each of the following factors substantially contributed to the mishap: (1) an external wing fuel imbalance of at least 750 pounds fuel imbalance; (2) F-15D left yaw/roll phenomenon when configured with two external wing tanks; and (3) a radome imperfection. After the mishap pilot recovered the aircraft from the spin, spatial disorientation hampered the dive recovery. I find clear and convincing evidence that at low altitude, this was also causal to the mishap and ultimately led to the mishap pilot's death.

Robert P Otto

30 September 2008

ROBERT P. OTTO, Brigadier General, USAF
President, Accident Investigation Board