# UNITED STATES AIR FORCE
# AIRCRAFT ACCIDENT INVESTIGATION BOARD REPORT

**QF-4E, T/N 68-0371**
**DETACHMENT 1, 82D AERIAL TARGETS SQUADRON**
**HOLLOMAN AIR FORCE BASE, NEW MEXICO**

**LOCATION: 70 MILES EAST OF HOLLOMAN AIR FORCE BASE**

**DATE OF ACCIDENT: 6 JULY 2011**

**BOARD PRESIDENT: LIEUTENANT COLONEL SHAWN E. ANGER**

**Conducted in accordance with Air Force Instruction 51-503**

# EXECUTIVE SUMMARY

## AIRCRAFT ACCIDENT INVESTIGATION
## QF-4E, T/N 68-0371, 70 Miles East of Holloman AFB NM
## 6 JULY 2011

On 6 July 2011 at approximately 1014 local time (L), the Mishap Aircraft (MA), a QF-4E, Tail Number 68-0371, departed controlled flight during an Adversary Support Training (AST) mission and impacted the ground approximately 70 miles east of Holloman AFB, New Mexico. The Mishap Pilot (MP) ejected safely and landed approximately one mile northwest of the MA crash site. The MA and MP were assigned to Detachment 1, 82d Aerial Targets Squadron at Holloman AFB. The MA was totally destroyed upon impact with the loss valued at $2,405,543.84. The MP sustained only minor injuries. There was no damage to personal property.

The Mishap Sortie was planned, briefed, and flown as an AST mission to gain proficiency in coordinated maneuvers and communication contracts. The Mishap Flight consisted of three aircraft. The MP flew as the training platform against Mishap Wingman 1 (MW1) and Mishap Wingman 2 (MW2). The mishap training scenario was the second scenario planned for the mission. The objective of the scenario was for MW1 and MW2 to work together to achieve a simulated kill against the MP. After flying past MW1's aircraft, the MP started a right hand turn to begin maneuvering towards MW2. After completing about 45 degrees of turn, the MA experienced a rapid un-commanded pitch up resulting in an estimated 9 G loading. The high G loading caused the MA to rapidly rotate to an extremely nose-high orientation. The MP properly executed the initial steps for out of control recovery in accordance with the emergency checklist. The MP was not able to regain control of the MA and decided to eject.

Post-mishap wreckage inspection clearly revealed the stabilator (stab) actuator, which controls aircraft pitch, had come disconnected from the MA. The locking tab washer which secures the stab actuator to the MA was improperly manufactured and had failed due to fatigue. Because the locking tab washer became disconnected, the actuator piston spun free from the rod-end due to aircraft vibrations; this resulted in a complete loss of pitch control of the MA. Engineering analysis also revealed the jam nut to rod-end of the mishap stab actuator was not sufficiently tightened, allowing the tab washer to weaken over a period of time.

The Accident Investigation Board President found by clear and convincing evidence the cause of the mishap was the stab actuator disconnecting from the MA, causing the MA to depart controlled flight. The stab actuator disconnected because of a material failure of its locking tab washer. Additionally, the Board President found by a preponderance of the evidence a substantially contributing factor to the mishap was an insufficiently tightened stab actuator jam nut.

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

# SUMMARY OF FACTS AND STATEMENT OF OPINION
# QF-4E, T/N 68-0371
# 6 JULY 2011

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# COMMONLY USED ACRONYMS & ABBREVIATIONS

| | |
|---|---|
| 53 WEG | 53d Weapons Evaluation Group |
| 53 WG | 53d Wing |
| 82d ARTS | 82d Aerial Targets Squadron |
| ACC | Air Combat Command |
| AFB | Air Force Base |
| AFI | Air Force Instruction |
| AFIP | Armed Forces Institute of Pathology |
| AFRL | Air Force Research Laboratory |
| AFTO | Air Force Technical Order |
| AGL | Above Ground Level |
| AIB | Accident Investigation Board |
| AM1 AM | ARG Maintainer 1 |
| AM2 AM | ARG Maintainer 2 |
| AMARG | Aerospace Maintenance and Regeneration Group |
| AR Aerial | Repair |
| ABQ ARTCC | Albuquerque Air Route Traffic Control Center |
| AST A | dversary Support Training |
| Bingo | End of Fuel, Return to Base |
| BP Bo | ard President |
| BPO Basic | Post Flight |
| CAD/PAD Cartrid | ge Actuated Device/Propellant Actuated Device |
| CAF | Combat Air Force |
| CAP | Combat Air Patrol |
| CMMXS Co | mmodities Maintenance Squadron |
| Det Detachm | ent |
| DLA Defe | nse Logistics Agency |
| DO Director | of Operations |
| DoD Depa | rtment of Defense |
| DT1 | Depot Technician 1 |
| EP Em | ergency Procedure |
| FCF | Functional Check Flight |
| FE Fl | ight Engineer |
| Freq Fre | quency |
| FS Flight | Surgeon |
| G Grav | itational Constant |
| HFACS | Human Factors Analysis and Classification System |
| HMN | Holloman Air Force Base |
| IAW In | Accordance With |
| IMDS | Integrated Maintenance Data System |
| IP Inst | ructor Pilot |
| ITCTO | Interim Time Compliance Technical Order |
| KIAS | Knots Indicated Airspeed |
| L Local | Time |
| MA | Mishap Aircraft |
| MF | Mishap Flight |
| MM1 | Mishap Maintainer 1 |
| MM2 Mish | ap Maintainer 2 |
| MOA | Military Operating Area |
| MP | Mishap Pilot |
| MS | Mishap Sortie |
| MSL | Mean Sea Level |
| MSW1 | Mishap Wingman 1 |
| MSW2 | Mishap Wingman 2 |
| NOTAM | Notice to Airmen |
| OCF | Operational Check Flight |
| OJT | On-the-Job Training |
| OO-ALC | Ogden Air Logistics Center |
| Ops Sup | Operations Supervisor |
| OSC | On-Scene Commander |
| OSHA | Occupational Safety and Health Administration |
| PE | Personal Evaluation |
| PHA | Preventative Health Assessment |
| PLF | Parachute Landing Fall |
| PMT | Pre-Mission Test |
| P/N | Part Number |
| PR | Preflight |
| QA | Quality Assessment |
| RCC | Resource Control Center |
| RFQ | Request for Quote |
| ROE | Rules of Engagement |
| ROW | Roswell Industrial Air Center |
| RTB | Return to Base |
| SAR | Search and Rescue |
| SII | Special Interest Item |
| S/N | Serial Number |
| SOF | Supervisor of Flight |
| SPF | Single Point of Failure |
| Stab Actuator | Stabilator Power Control Cylinder |
| Stabilator | Controls pitch (nose up/nose down) of aircraft |
| TCTO | Time Compliance Technical Order |
| TDY | Temporary Duty |
| T/N | Tail Number |
| T.O. | Technical Order |
| TEDT-WST-A | White Sands Missile Range, Army Air |
| USAFWC | United States Air Force Warfare Center |
| WX Weathe | r |

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

# SUMMARY OF FACTS

## 1. AUTHORITY AND PURPOSE

### a. Authority

On 5 August 2011, Lieutenant General William J. Rew, Vice Commander, Air Combat Command (ACC), appointed Lieutenant Colonel Shawn E. Anger as the Accident Investigation Board (AIB) President to investigate the 6 July 2011 mishap of a QF-4E aircraft, Tail Number (T/N) 68-0371. An AIB was conducted at Holloman Air Force Base (AFB), New Mexico, from 15 August 2011 to 9 September 2011, pursuant to Air Force Instruction (AFI) 51-503, *Aerospace Accident Investigations*. A Legal Advisor and Recorder were also appointed to the AIB. A pilot, doctor, and maintainer were detailed as Functional Area Experts. (Tab Y-3 to Y-6)

### b. Purpose

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

## 2. ACCIDENT SUMMARY

On 6 July 2011 at approximately 1014 local time (L), the Mishap Aircraft (MA), a QF-4E, T/N 68-0371, departed controlled flight during an Adversary Support Training (AST) mission and impacted the ground approximately 70 miles east of Holloman AFB. (Tabs J-3, J-13, M-3, and V-2.2) The Mishap Pilot (MP) ejected safely and landed approximately one mile northwest of the MA crash site. (Tabs J-3 and S-5) The MA and MP were assigned to Detachment 1, 82d Aerial Targets Squadron at Holloman AFB. The MA was totally destroyed upon impact with the loss valued at $2,405,543.84. (Tab P-3) The MP sustained only minor injuries. (Tab X-3) There was no damage to personal property. (Tab P-5)

## 3. BACKGROUND

### a. Units and Organizations

#### (1) Air Combat Command (ACC)

ACC, headquartered at Joint Base Langley-Eustis, Virginia, is a major command of the United States Air Force and primary force provider of combat airpower to America's warfighting commands. Its mission is to organize, train, equip, and maintain combat-ready forces for rapid deployment and employment while ensuring strategic air defense forces are ready to meet the challenges of peacetime air sovereignty and wartime air defense. ACC operates fighter, bomber, reconnaissance, battle-management, and

electronic-combat aircraft. It also provides command, control, communications, and intelligence systems and conducts global information operations . ACC's forces are organized under a direct reporting unit, three numbered air forces and one Air Force Reserve numbered air force. ACC's workforce is comprised of more than 96,000 active duty members and civilians, and when mobilized, more than 57,000 Air National Guard and Air Force Reserve members. In total, they operate more than 2,000 aircraft. (Tab CC-3 to CC-6)

**(2) United States Air Force Warfare Center (USAFWC)**

The USAFWC is headquartered at Nellis AFB, Nevada, and reports directly to ACC. The USAFWC exists to ensure deployed forces are well trained and well equipped to conduct integrated combat operations. To that end, the Center's mission is operational testing, tactics development, and advanced training in air, space, and cyberspace. To execute its mission, the USAFWC oversees the operations of five wings, comprised of approximately 10,000 active duty, guard, reserve, and civilian personnel located at 31 different locations. (Tab CC-8 to CC-9)

**(3) 53d Wing (53 WG)**

The 53 WG, located at Eglin AFB, Florida, reports directly to the USAFWC and serves as the focal point for the Combat Air Forces in electronic warfare, armament and avionics, chemical defense, reconnaissance, and aircrew training devices. The wing is responsible for operational testing and evaluation of new equipment and systems proposed for use by these forces. Current wing initiatives include advanced self-protection systems for combat aircraft, aircrew life support systems, aerial reconnaissance improvements, new armament and weapons delivery systems, and improved maintenance equipment and logistics support. (Tab CC-11 to CC-19)

**(4) 53d Weapons Evaluation Group (53 WEG)**

The 53 WEG, located at Tyndall AFB, Florida, reports directly to the 53 WG and conducts the Air Force's air-to-air and air-to-ground Weapon System Evaluation Programs. The 53 WEG is comprised of five squadrons and two detachments. Unit personnel provide all Air Force aerial target support for Department of Defense (DoD) users in the Gulf Ranges and full-scale targets for Title 10 testing at White Sands Missile Range, New Mexico, and Holloman AFB. (Tab CC-21 to CC-23)

**(5) Detachment 1, 82d Aerial Targets Squadron (Det. 1, 82 ATRS)**

Det. 1, 82 ATRS, is located at Hollomman AFB and operates and maintains a portion of the QF-4 full-scale aerial target fleet for use at the White Sands Missile Range. The squadron manages all contract operations of its QF-4 fleet as part of the overall Operations and Management contract at Tyndall AFB. In addition to Air Force programs such as the F-22, F-35, AIM-9X, and AIM-120, the detachment also supports Army surface-to-air programs and foreign military customers as well. The detachment employs a mixture of active duty, civilian and contractor personnel. (Tab CC-21 to CC-23 and CC-25)

**b. Aircraft: QF-4**

The supersonic QF-4 is a reusable full-scale target drone modified from the F-4 Phantom. The QF-4 provides a realistic full-scale target for air-to-air weapons system evaluation, development, and testing at Tyndall AFB and Holloman AFB. The QF-4, which can be flown by remote control or with a safety pilot to monitor its performance, is a remotely controlled target that simulates enemy aircraft maneuvers. The QF-4 is equipped to carry electronic and infrared countermeasures to fully evaluate fighters and weapons flown and fired against it. The drone is flown unmanned when missiles are fired at it, and only in specific over-water airspace authorized for unmanned flight. (Tab CC-27 to CC-28)

First flown in May 1958, the F-4 Phantom II originally was developed for U.S. Navy fleet defense and entered service in 1961. Throughout the 1960s and 1970s, the F-4 was the Air Force's primary fighter-bomber aircraft. The F-4s also flew reconnaissance and "Wild Weasel" anti-aircraft missile suppression missions. Phantom II production ended in 1979. The modified F-4 became the QF-4 and it is the successor to the QF-106 in the Air Force drone inventory. The QF-4 program attained initial operational capability in 1997. The aircraft has a wingspan of 38 feet, 15 inches, weighs 30,328 pounds, flies up to 1,600 miles per hour (Mach 2), has a ceiling of 60,000 feet, and has a range of 1,300 miles. (Tab CC-27 to CC-28)

## 4. SEQUENCE OF EVENTS

**a. Mission**

The Mishap Sortie (MS) was planned, briefed, and flown as an AST mission to gain proficiency in coordinated maneuvers and communication contracts. (Tabs K-9 and V-2.2) AST missions simulate adversary aircraft in support of Combat Air Force air-to-air training scenarios. (Tab V-3.3) The Mishap Flight (MF) consisted of three aircraft. Mishap Wingman 1 (MW1) simulated the lead adversary aircraft and was the overall flight lead for the mission. Mishap Wingman 2 (MW2) simulated a second adversary aircraft and flew as number two in the formation. The MP flew as the training platform against MW1 and MW2 and flew as number three in the mishap formation. (Tab V-3.3) The MS was scheduled for 1000L on 6 July 2011.

The Det. 1, 82 ATRS commander is the overall approval authority for missions; MW2 exercised delegated authority and approved the MS. (Tabs K-7 and V-1.3)

**b. Planning**

MW1 began mission planning the day prior to the MS. MW1 completed the remaining mission planning requirements the morning of the MS. (Tab V-2.3)

The mission brief began at 0815L, fifteen minutes earlier than the standard briefing requirement to allow additional time to review the training events planned for the MS. MW1 briefed the mission using a PowerPoint presentation that included all required briefing items in accordance with (IAW) standard operating procedures. (Tab V-1.4 and V-2.3) The MP, MW1, and MW2 were the only personnel to attend the brief. (Tab V-2.9)

**c. Preflight**

On the morning of the mishap, there was a late change of assigned aircraft to ensure the training platform aircraft (flown by MP) was distinguishable from the simulated adversary aircraft (flown by MW1 and MW2). (Tabs K-9 and V-1.3) The MP, MW1, and MW2 received a step brief, a short brief of current conditions and procedures that might affect the flight, from the Operations Supervisor (Ops Sup) at approximately 0910L. (Tab K-5) The MS was scheduled to operate in the Talon airspace, located approximately 65 miles east of Holloman AFB. (Tabs S-3 and V-1.5) The MF was filed on a standard flight plan. (Tabs K-3, K-9, and V-1.5)

After the step brief, the MP checked the maintenance forms, gathered the required life support equipment, and proceeded to the MA. (Tab V-1.11) The MA was configured with wing pylons and a centerline fuel tank. (Tab J-3) The rear cockpit ejection seat was not installed in the MA. (Tab H-5) The MP completed the exterior inspection, which is a visual inspection of the aircraft to check the general condition of the airframe, landing gear, engines, brakes, and flight controls. The MP did not find anything remarkable during the exterior inspection. The MP climbed into the cockpit and completed all required steps prior to engine start. (V-1.4) At approximately 0930L, the MP uneventfully started both engines of the MA. (Tabs K-5 and V-1.4)

**d. Summary of Accident**

The MP taxied on time at 0945L. The MP, MW1, and MW2 took off at 0956L using separate single-ship takeoff procedures. (Tabs K-5, N-5, N-7, and V-1.5) The flight to the training area was uneventful. (Tab V-1.5 and V-3.3) En route, the MP, MW1, and MW2 each executed a G-awareness exercise, a maneuver meant to prepare pilots for the increased physiological stresses caused by aggressive maneuvering. (Tab V-3.3) The MP, MW1, and MW2 then began the training scenarios. The MP executed the first training scenario without incident. (Tab V-2.3 and V-3.3)

The mishap training scenario was the second scenario planned for the mission. (Tab V-1.5) The objective of the scenario was for MW1 and MW2 to work together to achieve a simulated kill against the MP. MW1 and MW2 were training to fly as simulated adversaries, while the MP was

acting as the training platform . (Tab V-3.3) At the start of the scenario, MW1 and MW2 were positioned facing the same direction, lined up adjacent to each other with approximately 6,000 to 9,000 feet between their aircraft. The MP started facing the opposite direction at approximately 5 to 6 nautical miles in front of MW1 and MW2. (See Figure 1) (Tab K-5) During the briefed scenario, MW1 and MW2 and the MP are supposed to fly toward each other. As MW1 and the MP fly past each other, they begin to maneuver in relation to one another. MW2, who is adjacent to the fight, acts as the supporting fighter, helping MW1 defeat the training platform as quickly as possible while de-conflicting from the other two aircraft. (Tab V-2.4 and V-3.3)

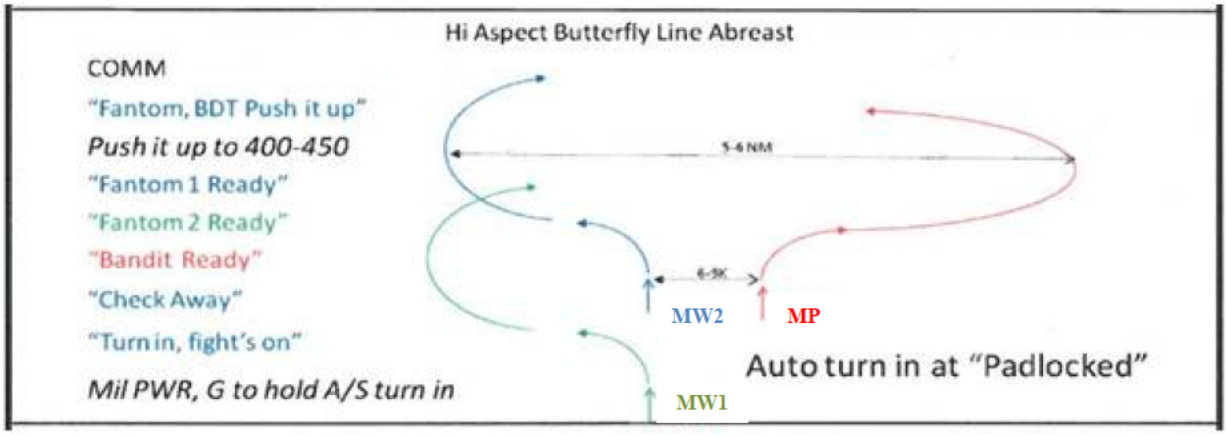


Figure 1. Planned Training Scenario

The setup for the scenario was uneventful. MW1 and MW2 and the MP flew towards each other as planned. The MP and MW1 approached each other from the right side of their respective aircraft. The only deviation from the briefed scenario was that MW2 lined up on the left side of MW1. This allowed the MP to pursue MW2 after having passed MW1, making the scenario more challenging. (Tab V-1.5 and V-2.4) After flying past MW1's aircraft, the MP started a right hand turn to begin maneuvering towards MW2. (Tab V-1.6) At the initiation of the right hand turn, the MP was flying at approximately 450 Knots Indicated Airspeed (KIAS), 10,000 feet Above Ground Level (AGL), and 4.5 Gs. (Tab J-3) Gs refer to the equivalent amount of force experienced by the aircraft and pilot in relation to the gravitational constant experienced on Earth. 4.5 Gs would be equivalent to experiencing a force 4.5 times greater than the natural force of gravity. After completing about 45 degrees of turn, the MA experienced a rapid un-commanded pitch up resulting in an estimated 9 G loading. (Tabs J-3 and V-1.6) The high G loading caused the MA to rapidly rotate to an extremely nose-high orientation. (Tab V-1.6 and V-2.5) The MP properly executed the initial steps for out of control recovery IAW the Technical Order (T.O.) 1F-4E-1 checklist. The MP did not feel the MA was out of control, however, standard operating procedures direct the pilot to apply the initial steps of the checklist for reduced control situations or small departures from controlled flight. (Tab V-1.6) Reduced control is a flight condition where the aircraft is not out of control, yet is not responding adequately to control inputs. The QF-4 will occasionally have small departures from controlled flight, which are easily recoverable by applying the same checklist procedures. (Tab V-1.6 and V-2.4)

While still in an extremely nose-high orientation, the MA began an un-commanded wing rock about 45 degrees in each direction. (Tab V-1.7) MW1 was still facing away from the MP during the initiation of the MA oscillations. (Tab V-2.4) Due to the setup of the scenario, MW2 was in a position to observe the MA and noticed the rapid rotation of the MA was highly irregular and far beyond the maneuvering limitations of the QF-4. As the wings of the MA started to oscillate, MW2 called out on the radio, "You're out of control!" (Tab V-3.4) MW1 heard this call and continued to turn back towards the MP to try and regain sight of the MA. MW 1 was able to reacquire the MA visually and similarly noticed the extreme nose- high attitude of the MA. (Tab V-2.4) The MP was not able to regain control of the MA and decided to eject. (Tab V-1.7) The QF-4 uses an uncontrolled ejection altitude of 10,000 feet AGL. (Tab V-2.9) The MP was very close to crossing the 10,000 feet AGL ejection altitude at the onset of the out of control condition. (Tab V-1.6 to V-1.7) At approximately 1014L, the MP safely ejected from the MA. (Tabs J-13, M-3, and N-21)

**e. Impact**

The MA impacted the ground at approximately 1015L. (Tabs M-3 and N-21) The impact site was approximately 70 miles east of Hollomon AFB on U.S. Government-owned property managed by the Bureau of Land Management. (See Figure 2) (Tabs J-3 and P-5)

Figure 2. Mishap Aircraft Impact Site Facing North

The terrain consisted of a relatively level desert environment. The ground scar was approximately 40 feet long, 25 feet wide, and 1.5 feet deep. The wreckage scattered primarily forward and left of the impact site, with the debris field measuring approximately 300 feet by 600 feet. Because the mishap occurred early into the MS, the MA had an estimated 10,000 pounds of fuel onboard, resulting in a significant ground fire after impact. (Tabs H-5 and J-3)

### f. Egress and Aircrew Flight Equipment

After an unsuccessful attempt to regain control of the MA, the MP initiated the ejection sequence by pulling the lower ejection handle located between the MP's legs. The ejection sequence was initiated within the performance envelope of the system. (Tab H-3) All egress system components functioned as designed. (Tab H-7) It took about six minutes for the MP to descend under canopy until landing on the ground at approximately 1021L. (Tabs N-22 and V-1.8) The MP landed in a small ravine about one mile northwest of the MA impact site and sustained minor injuries. (Tabs S-5, V-1.8, and X-3) The emergency air traffic control signal (squawk) and the emergency location transmitter beacon both automatically activated upon ejection and functioned as designed. (Tabs M-3 and N-21) The MP turned the locator beacon off once he was on the ground and was in contact with MW1 and MW2 flying overhead. (Tab V-2.6 and V-3.4)

A qualified aircrew flight equipment technician and cartridge actuated device/propellant actuated device equipment specialist evaluated the life support gear and confirmed all subsystems worked as designed. (Tab H-13) An eight inch by three inch tear was discovered in the canopy and is believed to have been caused by the drogue slug during canopy inflation. (See Figure 3) (Tab H-7 and H-13) The tear did not have an effect on the performance of the parachute. (Tab H-7)

Figure 3. Drogue Chute Hanging Through Canopy Tear

### g. Search and Rescue (SAR)

After the MP ejected from the MA, MW1 was able to visually acquire the MP's parachute, and subsequently followed the parachute down until the MP landed on the ground. MW2 was able to keep the MA in sight all the way through ground impact. The MA impacted the ground at approximately 1015L. (Tabs M-3 and N-21)

MW2 made the initial emergency call to Albuquerque Air Route Traffic Control Center (ABQ ARTCC) immediately following the MA's ground impact. MW2 confirmed they had seen a good parachute deployment and relayed the position of the downed aircraft in relation to a common reference point. (Tab N-21) ABQ ARTCC then notified the Holloman AFB Supervisor of Flight (SOF) of the mishap via a direct phone line to the Holloman AFB control tower. The SOF initiated the downed-aircraft checklist and contacted the Holloman AFB Command Post. (Tab R-9) Command Post initiated SAR efforts by contacting the White Sands Missile Range Army Air unit located at Holloman AFB at approximately 1030L. (Tabs R-10 and AA-3)

MW1 and MW2 coordinated between their two-ship to execute the initial on-scene commander (OSC) responsibilities. (Tab V-3.4) MW1 flew in a low-altitude orbit directly over the MP, while MW2 flew in a high-altitude orbit over the crash site to act as a communications relay with ABQ ARTCC. (Tab V-3.4) MW1 made radio contact with the MP at approximately 1027L and the MP relayed that he was "OK." MW2 then relayed this information to ABQ ARTCC. (Tabs N-21 and V-3.4) MW1 stayed on scene until he needed to return to Holloman AFB due to low fuel. MW2 had slightly more fuel than MW1 and was able to stay on scene. (Tabs R-10 and V-3.4)

A flight of three T-38 aircraft from Holloman AFB were airborne on a training mission in the local area. The SOF diverted the T-38s to the mishap location to take over OSC responsibilities. (Tab R-10 to R-11) MW2 orchestrated a handoff with the T-38 flight and pointed out the MP's location on the ground. Low on fuel, MW2 returned to Holloman AFB without incident. (Tabs R-10 and V-3.5) Subsequently, the 49th Operations Group Commander at Holloman AFB ordered a fourth T-38 to launch to monitor the SAR efforts and relay communications back to the SOF and Command Post. (Tab R-11)

Army Air immediately responded to the SAR request from Command Post. At 1100L, approximately 30 minutes after the initial rescue call, Army Air launched a C-12 aircraft to take over OSC duties from the airborne T-38s. (Tabs R-10 and AA-3) At 1111L, Army Air launched a UH-1 helicopter with a Holloman AFB flight surgeon on board. The UH-1's departure was slightly delayed waiting for the arrival of the flight surgeon. (Tab AA-4) The C-12 arrived over the mishap site at 1120L and completed the changeover of OSC from the T-38s. (Tab V-1.8)

The first responders to the MP were two civilians from a ranch near the crash site, who stayed with the MP until the arrival of the UH-1 rescue helicopter (Tabs R-4 and V-1.9). The local fire chief responded to the MA crash site in order to control the brush fire caused by the crash. (Tabs R-5 and V-1.9)

The UH-1 arrived at the MP's location at approximately 1141L. The flight surgeon examined the MP and determined he had not sustained any serious injuries. The UH-1 departed the mishap site with the MP at approximately 1210L and arrived back at Holloman AFB at approximately 1240L. An ambulance transported the MP to Gerald Champion Regional Medical Center in Alamogordo, New Mexico. The C-12 remained over the mishap site until the UH-1 rescue helicopter left with the MP. (Tabs V-1.9, V-1.12, AA-3, AA-4, and AA-6)

A civilian rescue helicopter, launched from the Roswell International Air Center, also responded to the mishap. However, the Hollomman AFB SOF told ABQ ARTCC to cancel the civilian rescue effort because Hollomman AFB rescue assets were also responding. (Tab R-12) The civilian helicopter was en route to the MP when ABQ ARTCC instructed them to return to base. (Tab V-3.4) Additionally, Army Air launched two more UH-1 helicopters to transport security forces, the Interim Safety Board (ISB) president and an Air Force photographer to the MA crash site. (Tab AA-3)

### h. Recovery of Remains

This section is not applicable.

## 5. MAINTENANCE

### a. Forms Documentation

Det.1, 82d ATRS maintained the aircraft forms for the MA. Maintenance is documented on Air Force Technical Order (AFTO) 781 series forms and in the Integrated Maintenance Data System (IMDS). (Tabs D-5 to D-25 and U-3) AFTO 781 series forms are hard copy forms used to document various maintenance actions and are maintained in a binder that is specifically assigned to each aircraft. IMDS is an automated database of aircraft discrepancies, maintenance repair actions, and flying history. A comprehensive review of all AFTO 781 series forms and IMDS was accomplished and revealed the MA was airworthy prior to the MS. (Tab D-5 to D-25) At the time of the mishap, the MA total flight time was 6,219.4 hours. (Tab D-5)

### b. Inspections

Preflight (PR) inspections are required to be conducted within 72 hours prior to the flight. A PR was accomplished on the MA on the morning of the mishap. A production superintendant signed an exceptional release, which serves as a certification that the active forms were reviewed and ensures the aircraft is safe for flight. (Tab D-6) The PR inspection was completed at 0825L. However, the time was incorrectly annotated as 1125L on the AFTO Form 781H. (Tab U-7)

The QF-4 aircraft is due for a major inspection cycle after every 100 hours of flying time. The most recent major inspection of the MA was accomplished on 9 March 2010. Prior to the mishap, the MA had flown 81.9 flight hours since the last major inspection. (Tab D-3)

There were no overdue Time Compliance Technical Order (TCTO) inspections or scheduled inspections at time of the mishap. (Tab D-15 to D-25)

### c. Maintenance Procedures

The refurbishing process of the MA began at Davis-Monthan AFB, Arizona on 13 December 2005 and was completed on 9 May 2006. The MA had been stored at "The Bone Yard" at Davis-Monthan AFB and required refurbishing prior to a return to flight status. During the

refurbishing process, all aircraft hydraulic actuators are removed and replaced with overhauled actuators from Hill AFB, Utah. (Tabs D-27 and V-15.2) All QF-4 aircraft stabilator power control cylinders (stab actuators), which control aircraft pitch, are overhauled at Ogden Air Logistics Center (OO-ALC), Hill AFB and then reintegrated into the supply system. (Tab D-27)

When the stab actuators arrive at Davis-Monthan AFB from Hill AFB, they are typically installed in the aircraft without the need for rigging adjustments. When stab actuator adjustments are required, the technician adjusts the forward stick in the cockpit and does not change the stab actuator rigging that was initially set to specifications at Hill AFB. In addition, the technicians at Davis-Monthan AFB do not make any adjustments to the jam nut or tab washer components of the stab actuator. (Tabs D-27 and V-15.3)

### d. Maintenance Personnel and Supervision

A review of the training records for the Det. 1, 82d ATRS maintenance personnel who performed maintenance on the MA in the days prior to the mishap indicate they were properly qualified on the maintenance tasks performed. (Tab G-19 to G-28)

### e. Fuel, Hydraulic, and Oil Inspection Analysis

Analysis of the fuel, oil, and hydraulic fluids could not be conducted because they were consumed by the fire caused when the MA impacted the ground. (Tab J-3) Joint Oil Analysis Program records indicate both engines were code Alpha, a designation given when there is no adverse negative trending analysis evident that would halt continued flying operations. (Tab D-3) There is no evidence to indicate that fluids were relevant to the mishap.

### f. Unscheduled Maintenance

All necessary repairs or replacements were properly made when required, independent of maintenance schedules and were not relevant to the mishap. (Tab D-5 to D-25)

## 6. AIRCRAFT AND AIRFRAME

### a. Structures and Systems

Wreckage analysis was conducted by a team of three specialists from OO-ALC. Visual inspection revealed that portions of all major surfaces were located in the scatter pattern indicating aircraft breakup occurred on ground impact. The fuselage captured the stab surface position approximately at neutral. All primary flight control actuators were recovered. Of note, the stab actuator piston and rod-end were found disconnected and did not exhibit damage typical of ground impact. (See Figure 4) The jam nut was installed on the rod-end, safety wired to a portion of the tab washer. (See Figure 5) A disconnected stab actuator is a known single point of failure (SPF). (Tab J-4) A SPF is a part of a system that, if it fails, will stop the entire system from working.

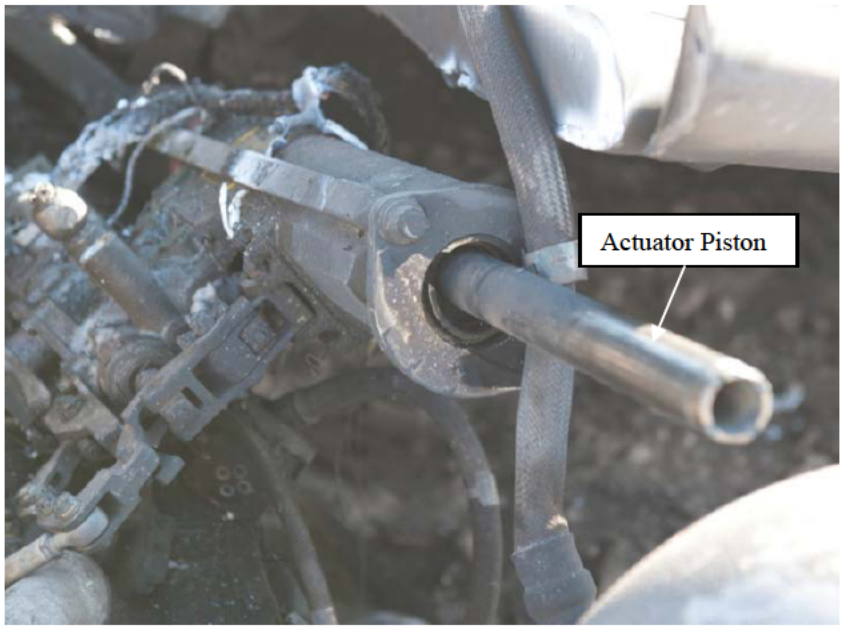


Figure 4. Stab Actuator

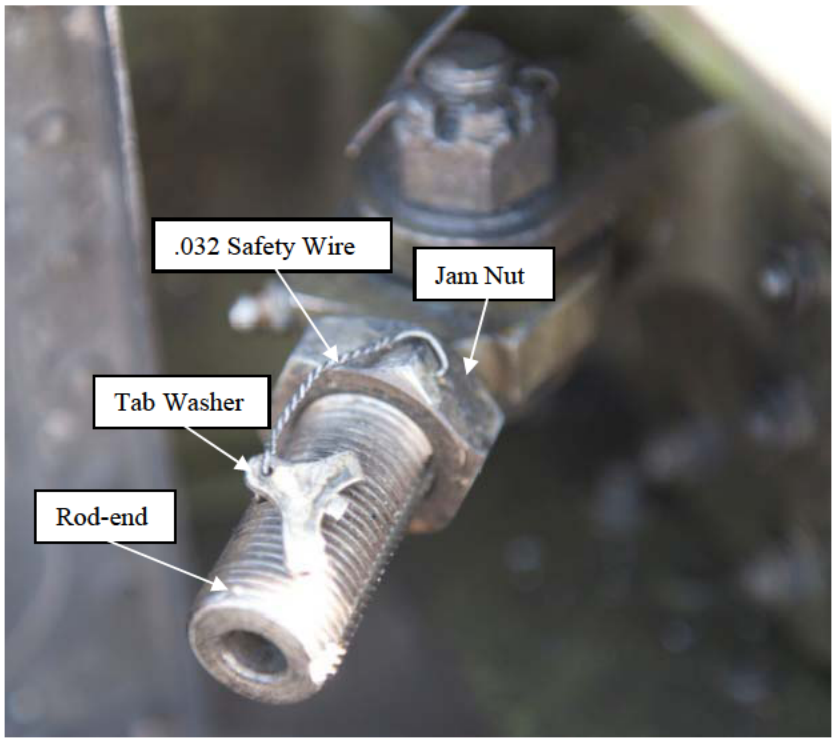


Figure 5. Disconnected Rod-End with Tab Washer Remnant

**b. Engineering Evaluations and Analyses**

OO-ALC analysis revealed th e stab actuator h ad im pact m arks equating to 20º leading edge down. This is in con trast to im pact m arks made by the stab on the MA em pennage which

indicated a neutral flight control position. The rod-end was found properly installed to the MA structure and disconnected from the piston with little damage. Damage was isolated to the initial full thread, which was folded over for approximately 270º. The direction of folding indicates failure under tension. (See Figure 6) (Tab J-4)

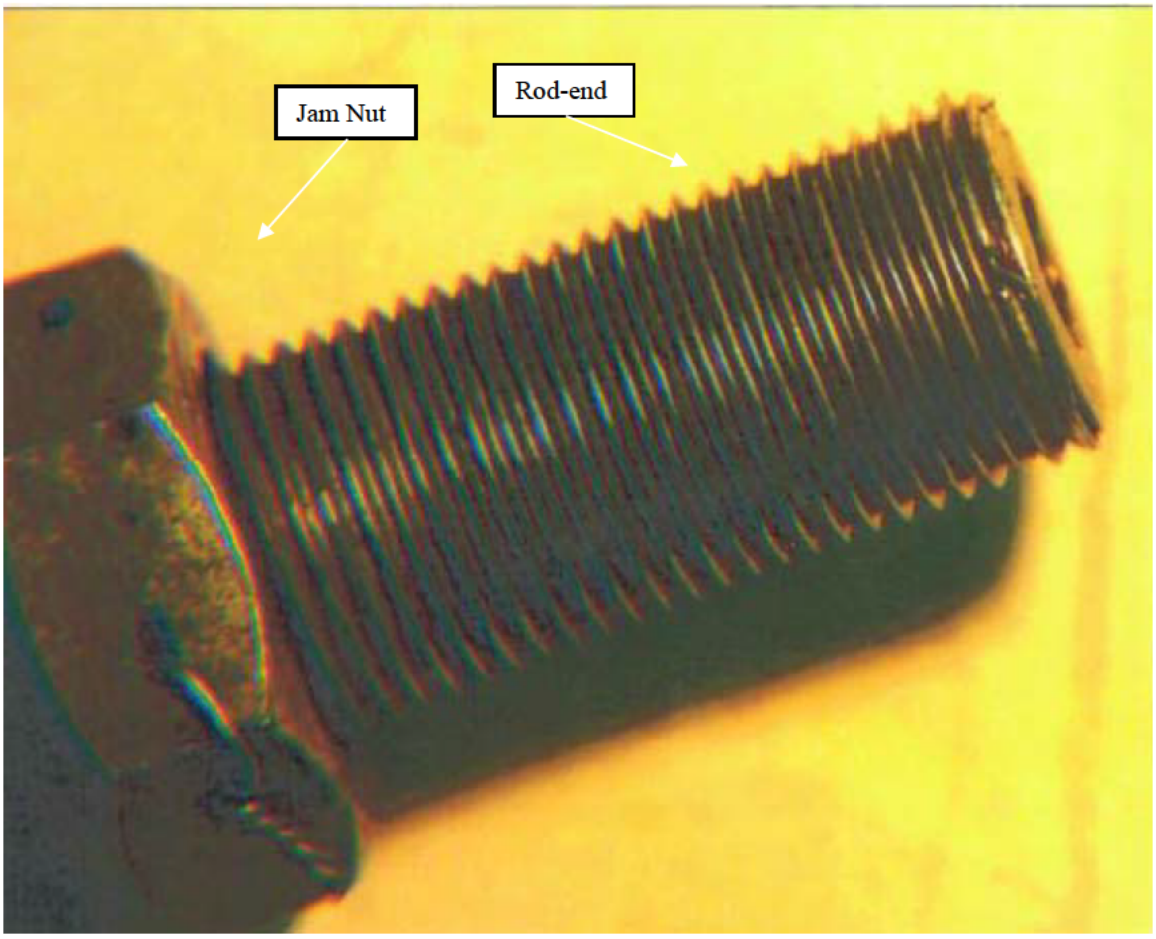


Figure 6. Threaded Rod-end Showing First Thread Failure

The jam nut was found properly installed to the rod-end with the safety wire attached to tab washer remnant to prevent back-off; there were no installation deficiencies noted. When the stab actuator is overhauled, the overhaul kit calls for tab washer, part number (P/N) 9M383-14, which replaces the original equipment manufacturer P/N 9M103-14. (See Figure 7) The difference is P/N 9M383-14 requires a solid locking tab rather than a U-shaped locking tab. The solid locking tab is a preferred geometry. (Tab J-5 to J-6)

Figure 7. P/N 9M383-14 (Left) and P/N 9M103-14 (Right)

The tab washer found attached to the mishap jam nut combines the thickness of the preferred P/N 9M383-14 tab washer and the obsolete stam ping process of the P/N 9M103-14 tab washer. (See Figure 8) This design does not meet current specifications. (Tab V-11.3)

Figure 8. Exemplar of Mishap Tab Washer (Left) and P/N 9M103-14 (Right)

The piston portion of the stab actuator was found properly installed to the body of the control cylinder. No damage to the rod-end mating threads was found. Visual inspection of the piston revealed smeared metal beginning at one of the wrench-flats and continuing up onto the face which serves as a seat for the tab washer, creating a raised surface or burr on this face. (Tab J-6)

OO-ALC determined the stab actuator disconnected prior to impact, based on the following three findings: the stab rod-end was disconnected from the piston with only one thread damaged on the rod-end, impact marks inside the actuator body show full extension at impact, and neutral stab surface position at impact. The integrity of threaded joints is dependent on proper joint assembly/clamp up. The joint integrity of the stab actuator rod-end was compromised prior to impact, allowing the piston to rotate inside the cylinder and disengage the rod-end. Disconnect of this joint occurred at approximately one thread engagement. The disconnection prior to impact would cause a loss of control of the stab actuator, which would cause a loss of pitch control of the MA. (Tab J-8)

The mechanism that resulted in a compromised joint is not known. Analysis concluded the compromised joint most likely occurred as a result of improper joint torque, improper seating of the washer in the piston slots, damage to the face of the piston end or jam nut, and/or joint design. Improper seating was dismissed due to a lack of crushing of the tabs on the recovered portion of the mishap tab washer. (Tab J-8)

Once disconnected, air loads drove the stab to a leading edge down position until contact with other structures occurred. Maximum deflection if disconnected is approximately 22º in lieu of 20-5/8º if properly rigged. Aero loads for a normally operating stab in the full leading edge down position coupled with slat deployment would result in vertical acceleration of 7.5 Gs at 390 KIAS or 9.7 Gs at 450 KIAS. Without slat deployment, the resulting vertical acceleration would be 5.8 Gs. (Tab J-8) This rapid onset, positive G condition is consistent with what the MP reported experiencing at the time of the mishap. (Tab V-1.6)

OO-ALC further analyzed the fractured ends of the mishap tab washer to determine the specific mode of failure. Using scanning electron microscopy, it was determined that the tab washer ends failed as a result of fatigue. Both fractured surfaces exhibited multiple plateaus which suggest reverse bending fatigue. (Tab J-34) A tab washer in a properly assembled joint is not subject to fatigue. (Tab J-8)

The Air Force Research Laboratory (AFRL) located at Wright-Patterson AFB, Ohio accomplished further failure analysis. As part of the overhaul process, a black oxide coating is applied to the actuator piston. This coating was present on the mishap piston and covered the raised burr present on the end of the piston. The presence of this coating suggests that the raised burr was present during the overhaul process and not as a result of damage due to MA ground impact. Additionally, an exemplar tab washer was used to investigate the joint properties. When the jam nut was hand tightened, no significant damage occurred to the burr. When the required 100 foot-pounds of torque was applied, the burr was crushed leaving a bright shiny surface. Figure 9 shows the raised burr before and after proper torque was applied. The lack of deformation to the burr on the mishap piston is evidence the jam nut was improperly tightened. (Tab J-15)

Figure 9. Burr Before Torque Applied (Left) and Burr After Torque Applied (Right)

**c. Hydraulic Stab Actuator (P/N 22930-1)**

The MA stab actuator is a known SPF. (Tab J-4) The life cycle of a QF-4 stab actuator begins during regeneration. During depot regeneration of QF-4 aircraft, the existing actuator is removed from the aircraft and replaced with an overhauled stab actuator. (Tab R-15) The MA stab actuator originated from Hill AFB in the 531st Commodities Maintenance Squadron. (Tab D-27) The 309th Aerospace Maintenance and Regeneration Group (AMARG) located at Davis-Monthan AFB installs 100% of these actuators and performs operational checks in cell four of the regeneration process. (Tab V-15.2) Cell five assesses the rigging of the actuator IAW T.O. guidance. Small adjustments are made in the cockpit area if required. No adjustments are made using the rod-end/piston connection of the stab actuator. (Tab V-15.3) Once regeneration is complete, the aircraft is flown to BAE Systems in Mojave, California for drone modifications. (Tab R-14) This modification is required to allow the aircraft to be flown remotely from a ground station. Modification procedures do not require adjustment of the stab actuator. (Tab D-31) Once drone modifications are complete, the aircraft is certified by a functional check flight and delivered to either Holloman AFB or Tyndall AFB for service. Once in service, routine maintenance inspections do not require specific checks of the stab actuator, specifically routine checks to determine if the jam nut is sufficiently tightened. (Tab U-5)

AFRL analysis determined that the jam nut of the mishap stab actuator was not sufficiently tightened at the time of the mishap, resulting in a torque value below required limits. This was determined by the lack of deformation of a pre-existing burr located at the end of the cylinder piston. (Tab J-15) Additionally, post-mishap torque values were requested from all existing stab actuators. These readings were taken from unflown actuators awaiting installation at AMARG and operational actuators in service at Holloman AFB and Tyndall AFB. Only 11.8% (2 of 17) met the required torque specification of 100-125 foot-pounds as detailed in T.O. 9H2-4-156-3. Of the actuators that have not seen service, 0% (0 of 4) met the required torque values. (Tabs BB-7 and DD-10)

### d. Tab Washer (P/N 9M103-14 and P/N 9M383-14)

Tab washers used on F-4 stab actuators were originally supplied under P/N 9M103-14. These washers were replaced with P/N 9M383-14 no later than 1 February 1972. (Tab BB-4) The design differences consist of tab washer thickness and overall manufacturing process. The P/N 9M103-14 washer requires a thickness of .035 ± .010 inch and the locking tabs are produced through a stamping process. The P/N 9M383-14 washer requires a thickness of .060 inch and the locking tabs are created through a casting process versus stamping. (Tab J-43) The mishap tab washer does not meet the design requirements of P/N 9M383-14. (Tab V-11.3) Instead of using a single casting for the washer to create the locking tabs, a stamping process was used. The mishap washer meets all P/N 9M103-14 dimensional requirements with the exception of thickness; therefore, it is at greater risk of cracking during forming operations. (Tab J-43) This phenomenon was validated by sectioning an exemplar tab washer of the same design as the mishap tab washer. Figure 10 shows the sectioned tab washer taken across the stamped portion of the locking tab. Figure 11 shows a crack in the stamped portion of the washer in a similar location to the failed mishap tab washer. A cadmium coating is applied to the entire tab washer after forming. Due to the presence of cadmium embedded in the crack, the crack is a result of the forming process and did not develop due to aircraft service loads. (Tab DD-34)

Figure 10. Sectioned Tab Washer

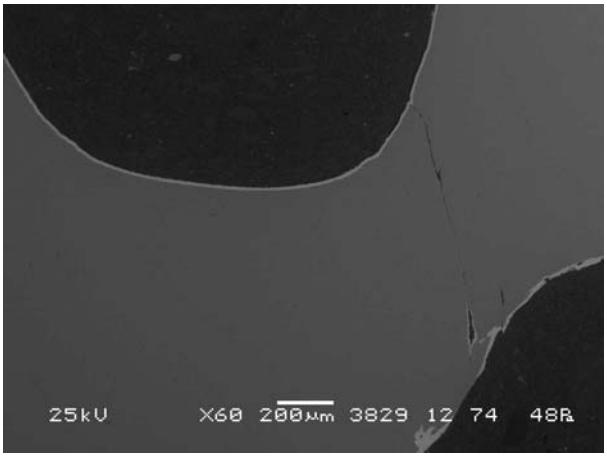


Figure 11. Crack in Tab Washer

During the stab actuator overhaul, an overhaul kit is used to replace various parts that are subject to wear. The tab washer is a 100% replacement part and is included as part of the rebuild kit. The rebuild kits are on contract with Moog Inc. Moog Inc. assembles the rebuild kits using specification drawings supplied by the Air Force. These drawings are handed down to distributers who subcontract out to manufacturers to produce the parts for Moog Inc. Moog Inc. uses four distributors: Anixter Aerospace, Transpec, Bisco Industries, and Kitco. These distributors subcontract to the following three manufacturers: Aerospace Products, Hasco, and Anillo Industries. Attempts to isolate the specific manufacturer of the deficient tab washer were inconclusive. Inspection of these kits is periodically accomplished by the Defense Contract Management Agency to ensure quality. (Tab EE-3 to EE-4)

## 7. WEATHER

### a. Forecast Weather

At brief time, weather for takeoff was forecast to have few clouds at 13,000 feet MSL and scattered clouds at 20,000 feet MSL, with winds out of the northeast, 020 degrees at 8 knots. (Tab F-6) Cloud layers in the Talon airspace were forecast to be few clouds between 13,000 and 15,000 feet MSL, and scattered clouds between 20,000 and 23,000 feet MSL. (Tab F-8)

### b. Observed Weather

The observed weather at takeoff was sky clear with calm winds. (Tab F-19) There was a cloud deck encountered on departure, causing the MF to momentarily level off at 13,500 feet MSL. Once clear of clouds, the MF was able to climb to the assigned block altitude of 21,000 to 22,000 feet MSL. (N-11) The weather in Talon airspace at the time of the mishap was sky clear and was not a factor to the mission. (Tab V-1.4 and V-3.6)

### c. Operations

Based on the forecast, the weather was within limits for the MS. Operations were conducted IAW applicable directives.

## 8. CREW QUALIFICATIONS

### a. Training

The MP was a qualified instructor pilot (IP) and flight examiner with 372.3 hours in the QF-4. (Tab G-3 and G-5) The MP was previously qualified as both an IP and a flight examiner with over 1,700 hours in the F-16. (Tab G-5 to G-7 and G-17) The MP completed initial qualification training in the QF-4 in June 2008. The MP then completed mission qualification training in July 2008 and IP upgrade training in October 2009. (Tab G-17) The MP completed all upgrades without incident. (Tab V-1.3) The MP was rated as a command pilot with over 2,500 total flying hours. (Tabs G-7 and T-5) The MP met all currency and training requirements prior to the MS and was qualified for the mission. (Tab G-10, G-11, and G-17)

### b. Experience

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

| | Hours | Sorties |
|---|---|---|
| 30 days | 11.2 | 9 |
| 60 days | 21.5 | 18 |
| 90 days | 29.6 | 24 |

MP qualifications were not contributory to this mishap. (Tab T-3)

## 9. MEDICAL

### a. Qualifications

The MP was medically qualified to perform QF-4 flying duties at the time of the mishap. The MP's annual Preventative Health Assessment (PHA) was current and a review of the Aeromedical Information and Medical Waiver Tracking System database showed one approved and current medical waiver during the time of the mishap. Furthermore, the MP had no physical or medical restrictions and was worldwide qualified prior to the mishap. (Tab X-3)

### b. Health

The MP's medical records, both hard copy and the electronic system Armed Forces Health Longitudinal Technology Application, were reviewed. According to the PHA on 10 December 2010, the MP was cleared medically for all duties except flying, pending the results of his waiver workup. His condition was waived on 11 January 2011 at which point he was returned to flying status. This condition did not factor into the mishap as either a cause or a contributory factor. (Tab X-3)

### c. Toxicology

Immediately following the mishap, toxicology testing was conducted by the ISB for all persons involved, including the MP and two civilian maintainers. The blood and urine samples were submitted to the Armed Forces Institute of Pathology (AFIP) for toxicology analysis of carbon monoxide and ethanol levels in the blood and to detect for any traces of drugs in the urine to include amphetamines, barbiturates, benzodiazepines, cannabinoids, cocaine, opiates, and phencyclidine. The toxicology samples arrived at AFIP in good condition. The results were universally negative for all members tested. (Tab X-3)

### d. Lifestyle

The MP's and mishap maintainers' lifestyle had no indication of unusual stresses, behaviors, or habits leading up to the mishap. (Tab X-3)

### e. Crew Rest and Crew Duty Time

All aircrew are required to have proper crew rest prior to performing flying duties as outlined in Air Force Instruction 11-202, Vol 3. Proper crew rest is defined as a minimum of a 12-hour non-duty period before the designated flight duty period begins. During this time, an aircrew member may participate in meals, transportation, or rest as long as he or she has had at least 10 hours of continuous restful activity with the opportunity for at least 8 hours of uninterrupted sleep. The MP met crew rest requirements. Although the MP had only 7 hours of sleep the night prior to the mishap, he recalled a well-rested state. Furthermore, 7 hours of sleep appears to be a normal amount of sleep for the MP. (Tab X-3)

## 10. OPERATIONS AND SUPERVISION

### a. Operations

Det. 1, 82 ATRS had a normal operations tempo described as low. (Tab V-2.2 and V-3.2) Pilots flew an average of two sorties per week. (Tab V-1.4 and V-2.2) The operations tempo had increased slightly due to the director of operations (DO) being deployed. (Tab V-1.4) The operations tempo was thoroughly investigated and found not to be a factor in the mishap.

### b. Supervision

The Ops Sup during the time of the mishap was fully qualified. The Ops Sup briefed the MF on all appropriate items during the preflight step brief. (Tabs G-3 and V-1.11) The Det. 1, 82 ATRS commander was on duty at the time of the mishap. The 82 ATRS DO was deployed overseas at the time of the mishap. (Tab V-1.4) MW1 and MW2 are experienced aviators and qualified flight leads in the QF-4. (Tabs G-3, V-2.2, and V-3.2) Operations supervision of the MS was thoroughly investigated and found not to be a factor in the mishap.

## 11. HUMAN FACTORS ANALYSIS

The Department of Defense Human Factors Analysis and Classification System (DoD-HFACS) is comprised of a list of potential human factors that can be contributory or causal to a mishap. The DoD-HFACS classification taxonomy describes four main tiers of human factors including Acts, Pre-Conditions, Supervision, and Organizational Influences. One human factor was identified and described below for this mishap:

*Organizational Influences* are factors in a mishap if the communications, actions, omissions or policies of upper-level management directly or indirectly affect supervisory practices, conditions or actions of the operator(s) and result in system failure, human error or an unsafe situation.

### OR004 Acquisition Policies/Design Processes

Acquisition Policies/Design Processes is a factor when the processes through which aircraft, vehicle, equipment, or logistical support are acquired allows inadequacies or when design deficiencies allow inadequacies in the acquisition and the inadequacies create an unsafe situation.

Investigation revealed there are two tab washers in circulation that are being used under the P/N 9M383-14. (Tab V-11.4) These washers are similar in that they are both the same thickness and they both fit the jam nut used on the stab actuator. The preferred tab washer is of a solid design whereas the mishap tab washer is a stamped design. The mishap tab washer is prone to fatigue failure due to weakening of the material that develops during the stamping process. (Tab J-43) It is unknown who or what organization approved or classified this part as an acceptable substitute to the preferred solid tab washer with P/N 9M383-14.

## 12. GOVERNING DIRECTIVES AND PUBLICATIONS

### a. Primary Operations Directives and Publications

(1) AFI 11-2F/QF-4, Volume 1, *QF-4 Aircrew Training*, 1 October 2003
(2) AFI 11-2F/QF-4, Volume 2, *QF-4 Aircrew Evaluation Criteria*, 5 July 2011
(3) AFI 11-2F/QF-4, Volume 3, *F/QF-4 Operations Procedures*, 1 July 2000
(4) AFI 11-202, Volume 3, *General Flight Rules,* 22 October 2010
(5) AFI 11-214, *Air Operations Rules and Procedures*, 22 December 2005, *Change 2*, 02 June 2009
(6) AFI 91-204, *Safety Investigations and Reports*, 24 September 2008, DOD HFACS QF -4 Phase Manual, *QF-4 Pilot Procedures*, 1 March 2004
(7) T.O. 1F-4E-1, *Basic F-4 Flight Manual*, 15 October 1984

### b. Maintenance Directives and Publications

(1) AFI 10-220, *Contractor's Flight and Ground Operations*, 01 March 2007
(2) T.O. IF-4-1633C, *Time Compliance Technical Order (TCTO),* 20 July 2011
(3) T.O. IF-4E-2-4, *Flight Control Systems*, 1 August 1978
(4) T.O. 9H2-4-156-3, *Overhaul Instructions,* 15 January 2005

### c. Other Directives and Publications

(1) T.O. 13A5-37-3, *O/H Inst – Rocket Assist Ejection Seat, Model MK-H7AF, Type MBEU38950-5 (Pilot), MBEU38952-5 (Radar Pilot),* 15 February 1991

## 13. ADDITIONAL AREA OF CONCERN

Post-mishap analyses of in-service stab actuator jam nuts reflect a significant departure from required T.O. torque values of 100-125 foot-pounds. (Tab BB-7) Proper clamp up is required for the jam nut-tab washer-piston joint to function properly. Since many of these actuators have been overhauled numerous years ago and have undergone various handling procedures to include the aircraft flight environment, it is impossible to precisely identify the source of low torque values. Although not deemed causal, insufficient jam nut torque is a contributory factor to the mishap.

9 September 2011

SHAWN E. ANGER, Lt Col, USAF
President, Accident Investigation Board

# STATEMENT OF OPINION
# QF-4E, T/N 68-0371 ACCIDENT
# 6 JULY 2011

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

## 1. OPINION SUMMARY

After extensive interviews and engineering analysis, I find by clear and convincing evidence that the cause of the mishap was the stab actuator disconnecting from the mishap aircraft (MA), causing the MA to depart controlled flight. The stab actuator disconnected because of a material failure of its locking tab washer, which did not meet design specifications such that the manufacturing process may induce material weakening along the locking tabs. Additionally, I find by a preponderance of the evidence that an insufficiently tightened jam nut to rod-end on the mishap stab actuator, which resulted in a torque value below specifications, was a substantially contributing factor to the mishap.

## 2. DISCUSSION OF OPINION

On 6 July 2011, at approximately 1014 local time, QF-4E tail number 68-0371, departed controlled flight under normal flight conditions and operating parameters. After an unsuccessful attempt to regain control, the mishap pilot (MP) safely ejected and sustained minor injuries. The MA crashed approximately 70 miles east of Holloman Air Force Base, New Mexico and was destroyed on impact. The mishap wreckage was engulfed in flames after impact and burned approximately 50 acres of nearby government land.

### a. Cause: Tab Washer Failure

Post-mishap wreckage inspection clearly revealed the stab actuator, which controls aircraft pitch, had come disconnected from the MA. The disconnection occurred where the actuator piston meets the rod-end that attaches to the bulkhead of the aircraft. A locking tab washer is used between a jam nut and the piston end to secure the joint. However, the tab washer failed.

Further inspection of the wreckage revealed approximately one-quarter of the mishap tab washer remained attached to its respective jam nut, which indicated the tab washer had failed. Failure of this joint will result in complete inability to control aircraft pitch. Engineering and visual analyses of the tab washer indicate a design inconsistent with prescribed engineering drawings for a part number 9M383-14 tab washer. Specifically, the tab washer should be a solid cast item. Manufacture of the mishap washer used a stamp process to form the locking tabs. By stamping these features, the material is significantly weakened around the area of greatest deformation.

These points of deformation effectively reduce the fatigue resistance of the washer. Due to this material deficiency, the tab washer failed and liberated itself from the joint. Without the locking tab washer, the piston end of the actuator was able to spin free from the rod-end. The disconnection prior to impact resulted in loss of pitch control of the MA and the MP was forced to eject.

### b. Substantially Contributing Factor: Insufficient Torque of the Jam Nut

Engineering analysis suggests the mishap piston/jam nut connection was not properly torqued to the required 100-125 foot-pounds in accordance with maintenance and overhaul Technical Orders. Specifically, a raised burr on the piston end (shown to be present during overhaul of the stab actuator) exhibited no deformation until after it was tightened to specification post-mishap. Additionally, the tab washer failed in fatigue. A properly clamped joint would not subject a tab washer to fatigue loads. However, an insufficiently tightened jam nut could cause the tab washer to experience cyclic loading from aircraft vibrations.

## 3. CONCLUSION

I find by clear and convincing evidence the cause of the mishap was the stab actuator disconnecting from the MA caused by the material failure of the stab actuator's tab washer, causing the MA to depart controlled flight. Additionally, I find by a preponderance of the evidence, the insufficiently tightened jam nut of the stab actuator was a substantially contributing factor to the mishap.

9 September 2011

SHAWN E. ANGER, Lt Col, USAF
President, Accident Investigation Board

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