

UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION
BOARD REPORT



F-16CJ, T/N 92-3890

UNITED STATES AIR FORCE AIR DEMONSTRATION SQUADRON
57th WING
NELLIS AIR FORCE BASE, NEVADA



LOCATION: EL PASO COUNTY

DATE OF ACCIDENT: 2 JUNE 2016

BOARD PRESIDENT: COLONEL BRIAN J. KAMP

Conducted IAW Air Force Instruction 51-503

[Volume One of One]



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

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5 DEC 2016

ACTION OF THE CONVENING AUTHORITY

The Report of the Accident Investigation Board, conducted under the provisions of AFI 51-503, that investigated the 2 June 2016 mishap involving F-16CJ, T/N 92-3890, United States Air Force Air Demonstration Squadron (USAFADS), 57th Wing, Nellis Air Force Base, Nevada, complies with applicable regulatory and statutory guidance; on that basis it is approved.

//Signed//

JERRY D. HARRIS, JR.
Major General, USAF
Vice Commander

Agile Combat Power

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO EXECUTIVE SUMMARY UNITED STATES AIR FORCE AIRCRAFT ACCIDENT INVESTIGATION

**BLOCK 52 F-16CJ, T/N 92-3890
EL PASO COUNTY, CO
2 JUNE 2016**

On 2 June 2016 at 13:00 local time an F-16CJ was destroyed by ground impact after the Mishap Pilot (MP) ejected south of Peterson Air Force Base (AFB), CO. The MP sustained a minor injury and no other personnel were injured. The Mishap Aircraft (MA) Tail Number 92-3890 and the MP are assigned to the 57th Wing, United States Air Force Air Demonstration Squadron (USAFADS), Nellis AFB, NV. The MA, valued at \$29,466,037.00 (total government loss), was destroyed. There was no known damage to civilian property.

The mishap occurred as part of a six F-16 aircraft, USAFADS flyby and airshow combination for a United States Air Force Academy graduation ceremony, Colorado Springs, CO. The mission was uneventful until the MA entered the Peterson AFB traffic pattern in preparation for landing. When the MA was positioned on downwind (parallel to, and opposing the active landing runway), the highly experienced MP inadvertently placed the throttle to cutoff position (engine shutdown). This normally requires both (a) an actuation of the throttle cutoff release trigger switch (throttle trigger), which then permits (b) full throttle grip rotation outboard -- enabling the throttle to be retarded aft (pulled backwards), past the cutoff stop. Below the minimum altitude/airspeed required for either an engine restart or flame-out landing, the MP was forced to eject over a grass field in El Paso County, CO.

The throttle trigger must be physically actuated (depressed, squeezed, pulled) to overcome the spring-force in its un-actuated position. Analysis by Air Force Research Laboratory/Materials Integrity Branch identified intermittent sticking/binding of the MA throttle trigger, causing the throttle trigger to remain in the retracted/stuck position after actuation. The throttle trigger bushing was examined and determined to be damaged and worn due to throttle trigger clevis pin misalignment, along with metallic-particle debris contamination -- both increasing the chance of throttle trigger sticking/binding. In addition, lubricant to the throttle trigger assembly was identified (inconsistent with maintenance technical orders), which exacerbated the debris contamination condition.

The Accident Investigation Board President found by a preponderance of the evidence the cause of this mishap was a throttle trigger actuation and subsequent malfunction (throttle trigger stuck in retracted position) followed by the MP's inadvertent full-rotation of the throttle grip while retarding the throttle aft to cutoff position. Substantially contributing factors include maintenance Technical Orders that lack sufficient detail to consistently identify either a throttle trigger clevis pin misalignment or a sticking/binding throttle trigger.

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

United States Air Force Accident Investigation Board Report
F-16CJ Crash, El Paso County, CO
SUMMARY OF FACTS AND STATEMENT OF OPINION
F-16CJ, T/N 92-3890
2 JUNE 2016

TABLE OF CONTENTS

| | |
|--|-----|
| ACRONYMS AND ABBREVIATIONS..... | iii |
| SUMMARY OF FACTS..... | 1 |
| 1. AUTHORITY AND PURPOSE..... | 1 |
| a. Authority..... | 1 |
| b. Purpose..... | 1 |
| 2. ACCIDENT SUMMARY..... | 1 |
| 3. BACKGROUND..... | 2 |
| a. Air Combat Command..... | 2 |
| b. United States Air Force Warfare Center (USAFWC)..... | 2 |
| c. 57th Wing..... | 2 |
| d. United States Air Force Air Demonstration Squadron..... | 2 |
| e. F-16..... | 3 |
| 4. SEQUENCE OF EVENTS..... | 3 |
| a. Mission..... | 3 |
| b. Planning..... | 3 |
| c. Preflight..... | 3 |
| d. Summary of Accident..... | 4 |
| e. Impact..... | 8 |
| f. Egress and Aircrew Flight Equipment..... | 9 |
| g. Search and Rescue (SAR)..... | 9 |
| h. Recovery of Remains..... | 10 |
| 5. MAINTENANCE..... | 10 |
| a. Aircraft Forms & Documentation..... | 10 |
| b. Inspections..... | 10 |
| c. Maintenance Procedures..... | 11 |
| d. Maintenance Personnel and Supervision..... | 12 |
| e. Fuel, Hydraulic, and Oil Inspection Analyses..... | 12 |
| f. Unscheduled Maintenance..... | 13 |
| 6. AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS..... | 13 |
| a. Structures and Systems..... | 13 |
| b. Evaluation and Analysis..... | 18 |
| 7. WEATHER..... | 23 |
| a. Forecast Weather..... | 23 |
| b. Observed Weather..... | 24 |
| c. Space Environment..... | 24 |
| d. Operations..... | 24 |
| 8. CREW QUALIFICATIONS..... | 24 |
| a. USAFADS Pilot Waivers..... | 24 |
| b. Mishap Pilot..... | 25 |

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO

9. MEDICAL 26

 a. Qualifications 26

 b. Health 26

 c. Pathology/Toxicology 26

 d. Lifestyle 27

 e. Crew Rest and Crew Duty Time 27

10. OPERATIONS AND SUPERVISION 27

 a. Operations 27

 b. Supervision 27

11. HUMAN FACTORS analysis 28

 a. Introduction 28

 b. AE101 Inadvertent Operation 28

 c. OP003 Procedural Guidance/Publications 29

12. GOVERNING DIRECTIVES AND PUBLICATIONS 29

 a. Publically Available Directives and Publications Relevant to the Mishap 29

 b. Other Directives and Publications Relevant to the Mishap 29

 c. Known or Suspected Deviations from Directives or Publications 29

STATEMENT OF OPINION 30

1. OPINION SUMMARY 30

2. CAUSE 30

 a. Throttle cutoff release actuation and subsequent malfunction 30

 b. Inadvertent rotation of the throttle grip 31

3. SUBSTANTIALLY CONTRIBUTING FACTORS 31

 a. TOs lack sufficient detail to consistently identify throttle trigger clevis pin misalignment 32

 b. TOs lack sufficient detail to consistently identify sticking throttle cutoff release 32

4. CONCLUSION 32

INDEX OF TABS 33

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO ACRONYMS AND ABBREVIATIONS

| | | | |
|---------|--|--------|---|
| 57 WG | 57th Wing | HFAC | Human Factors Analysis & Classification |
| ACC | Air Combat Command | HPSK | Higher Priority Supply Kit |
| AFB | Air Force Base | HUD | Heads Up Display |
| AFE | Aircrew Flight Equipment | IAW | In Accordance With |
| AFI | Air Force Instruction | IFF | Introduction to Fighter Fundamentals |
| AFRL | Air Force Research Laboratory | IMDS | Integrated Maintenance Data System |
| AFTO | Air Force Technical Order | IP | Instructor Pilot |
| AGL | Above Ground Level | ISB | Interim Safety Board |
| AHC | Advanced Handling Characteristics | ITCTO | Interim Urgent Action Safety Time Compliance Technical Order |
| AIB | Accident Investigation Board | JFS | Jet Fuel Starter |
| AIMWTS | Aeromedical Information Management Waiver Tracking System | JSUPT | Joint Specialized Undergraduate Pilot Training |
| AMOPS | Airfield Management and Operations | LA | Legal Advisor |
| ARFF | Aircraft Rescue and Firefighting | LBS | Pounds |
| ATC | Air Traffic Control | LM | Lockheed Martin |
| BAQ | Basic Aircraft Qualification | MA | Mishap Aircraft |
| BMC | Basic Mission Capable | MICAP | Mission Capability |
| BLVD | Boulevard | MF | Mishap Flight |
| BPO | Basic Post Flight | MM | Mishap Maintainer |
| CAF | Combat Air Forces | MMC | Modular Mission Computer |
| CANN | Cannibalization | MP | Mishap Pilot |
| CAPS | Critical Action Procedures | MSL | Mean Sea Level |
| CC | Commander | NDN | No Discrepancy Noted |
| CMR | Combat Mission Ready | NM | Nautical Miles |
| CO | Colorado | NV | Nevada |
| COMACC | Commander, Air Combat Command | NCO | Noncommissioned Officer |
| CO ARNG | Colorado Army National Guard | NCOIC | Noncommissioned Officer in Charge |
| CSAF | Chief of Staff of the Air Force | NOTAMS | Notices to Airmen |
| DAS | Data Acquisition System | OPS | Operations |
| DAU | Data Acquisition Unit | ORM | Operational Risk Management |
| DOC | Designated Operational Capability | OSS | Operations Support Squadron |
| DoD | Department of Defense | OTI | One-Time Inspection |
| DRS | Digital Recover Sequencer | PA | Public Affairs |
| DVR | Digital Video Recorder | PDF | Portable Document Format |
| ECSMU | Enhanced Crash Survivable Memory Unit | PEX | Patriot Excalibur |
| EGI | Embedded Global positioning and Inertial navigation set | PLF | Parachute Landing Fall |
| EPEX | Electronic Patriot Excalibur | POTUS | President of the United States |
| EP | Emergency Procedure | PR | Public Relations |
| EPLA | Engine Power Lever Angle | PR | Preflight |
| EPU | Emergency Power Unit | RA | Resource Advisor |
| FAA | Federal Aviation Administration | RIV | Rapid Intervention Vehicle |
| FCIF | Flight Crew Information File | RPM | Revolutions Per Minute |
| FDP | Flight Duty Period | RSO | Range Safety Officer |
| FEF | Flight Evaluation Folder | SAR | Search and Rescue |
| FI | Fault Isolation | SARM | Squadron Aviation Resource Manager |
| FP | Fighter Pilot | SEPT | Supplementary Emergency Procedure Training |
| FTIT | Fan Turbine Inlet Temperature | SIB | Safety Investigation Board |
| G | Gravity | SII | Special Interest Item |
| GPS | Global Positioning Satellite | SIM | Simulator |
| HARM | Host Aviation Resource Management | | |

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO

| | | | |
|-------|---------------------------------|---------|--|
| SME | Subject Matter Expert | UHF | Ultra High Frequency |
| SOF | Supervisor of Flying | UPT | Undergraduate Pilot Training |
| SPO | System Program Office | USAF | United States Air Force |
| STBY | Standby | USAFADS | US Air Force Air |
| SUV | Sport Utility Vehicle | | Demonstration Squadron |
| TBIRD | Thunderbird | USAFWC | United States Air Force Warfare Center |
| TCTO | Time Compliance Technical Order | WAI | Walk Around Inspections |
| TDY | Temporary Duty | WG | Wing |
| TFR | Temporary Flight Restriction | WGI | Wing Instruction |
| TO | Technical Order | | |
| TS | Training Sortie | | |

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

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO

SUMMARY OF FACTS

1. AUTHORITY AND PURPOSE

a. Authority

On 14 July 2016, Major General Jerry D. Harris, Jr, Vice Commander, Air Combat Command (ACC), appointed Colonel Brian J. Kamp to conduct an aircraft accident investigation of the 2 June 2016 mishap of an F-16 Thunderbird aircraft in El Paso County, CO (Tab Y-2). On 20 July 2016, the Accident Investigation Board (AIB) convened at Nellis Air Force Base (AFB), NV. A maintenance member (Major), legal advisor (Captain), pilot member (Captain), medical member (Captain), and a recorder (Staff Sergeant) were appointed to the board (Tab Y-2). A subject matter expert (SME) in physiology (Captain) and an expert in biomechanics (Civilian Employee) were formally appointed on 9 August 2016 (Tabs Y-4 and Y-6). The AIB was conducted in accordance with Air Force Instruction (AFI) 51-503, Aerospace and Ground Accident Investigations, dated 14 April 2015, and AFI 51-503, ACC Supplement, Aerospace and Ground Accident Investigations, dated 28 January 2016.

b. Purpose

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

2. ACCIDENT SUMMARY

On 2 June 2016, at approximately 12:59 local time (L), a block 52 F-16CJ, tail number 92-3890 [Mishap Aircraft (MA)], assigned to the United States Air Force Air Demonstration Squadron (USAFADS), 57th Wing (57 WG), Nellis AFB, NV, experienced a loss of thrust while in the landing pattern at Peterson AFB, CO after a combined flyby and airshow at the United States Air Force (USAF) Academy (Tabs EE-5 and V-1.3 to V-1.4,). The MA crashed into an open field two miles south of Peterson AFB (Runway 35R) in El Paso County, CO (Tab EE-6 to EE-8). The Mishap Pilot (MP) safely ejected at 13:00L and suffered a minor injury (Tabs H-2, EE-14, DD-9, V-1.5 to V-1.6, V-1.27, and X-2). The MA impacted the ground and was destroyed approximately eight seconds after the MP ejected, resulting in a total government loss of \$29,466,037 (Tabs P-2 and EE-14). There was no known damage to civilian property (Tab P-2). Initial environmental clean-up costs were \$2,181.22 (Tab P-2).

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO

3. BACKGROUND

a. Air Combat Command

Air Combat Command is the primary force provider of combat airpower to America's warfighting commands (Tab CC-2). To support global implementation of national security strategy, ACC operates fighter, bomber, reconnaissance, battle-management and electronic-combat aircraft (Tab CC-2). It also provides command, control, communications and intelligence systems, and conducts global information operations (Tab CC-2). ACC's mission is to support global implementation of national security strategy. ACC operates over 1,300 aircraft across 34 wings and 19 bases, comprising over 94,000 active duty and civilian personnel (Tab CC-2).



b. United States Air Force Warfare Center (USAFWC)

The USAFWC's mission is to develop innovative leaders and full spectrum capabilities through responsive, realistic, and relevant testing, tactics development, and advanced training across all levels of war. (Tab CC-6) The USAFWC ensures deployed forces are well trained and well equipped to conduct integrated combat operations. USAFWC oversees the operations of four wings, two named units and one detachment, comprised of 11,000 personnel located in 23 states and 37 different locations (Tab CC-6).



c. 57th Wing

The 57 WG provides advanced aerospace training to world-wide combat air forces and showcases aerospace power to the world while overseeing the dynamic and challenging flying operations at Nellis AFB (Tab CC-8). The 57 WG is comprised of seven distinct organizations, and manages all flying operations at Nellis AFB and conducts advanced aircrew, space, logistics and command and control training through the USAF Weapons School, Red Flag and Green Flag exercises (Tab CC-8). The wing additionally supports the USAFWC's test/evaluation activities and showcases air power through the USAFADS "Thunderbirds" (Tab CC-8).



d. United States Air Force Air Demonstration Squadron

The USAFADS, also known as the Thunderbirds, performs precision aerial maneuvers demonstrating the capabilities of Air Force high performance aircraft to people throughout the world. The squadron exhibits the professional qualities the Air Force develops in the people who fly, maintain and support these aircraft (Tab CC-11).



United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO

e. F-16

The F-16 Fighting Falcon is a compact multi-role fighter aircraft. It is highly maneuverable and has proven itself in air-to-air combat and air-to-surface attack. It provides a relatively low-cost, high performance weapon system and air demonstration capabilities for the United States and allied nations (Tab CC-15).



4. SEQUENCE OF EVENTS

a. Mission

The mishap flight (MF) was comprised of six F-16CJs (Tabs K-2, V-1.14, and EE-5). The mission was to conduct a flyover of the USAF Academy graduation, followed by an airshow at the same location (Tab V-2.2). COMACC has the approval authority for Thunderbird flybys (Tab BB-19). The Chief of Staff of the Air Force (CSAF) and the Secretary of the Air Force, Public Affairs (SAF/PA) have approval authority for Thunderbird airshows (Tab BB-19). The USAFADS airshow is a series of precision maneuvers flown to maximize public exposure for the benefit of the USAF recruiting (Tab CC-11). The MF took off at approximately 12:04L from Peterson AFB, performed the show, and returned to Peterson AFB with the intention of landing (Tabs K-2, V-2.4, and EE-5). At approximately 13:00L the MP ejected from his aircraft (Tabs V-1.5 and EE-5).

b. Planning

Pilot 1, a squadron supervisor, conducted the brief prior to the mission using a personalized briefing guide (Tabs V-2.3 and AA-2). The brief to the MF was in accordance with (IAW) the USAFADS standards (Tabs V-1.21, V-1.22, V-2.2, and BB-22). In particular, the brief covered objectives, mission materials (specific to that day and that show site), flight administration, flyby timing administration, special subjects, Emergency Procedures (EPs), Special Interest Items (SIIs), Operational Risk Management (ORM), the show profile (low show high density altitude), and expected fuels throughout phases of flight to include a “joker fuel” (fuel state needed to transition from one phase of flight to another) and “bingo fuel” (prebriefed fuel state needed for recovery to the designated airfield of intended landing) (Tab V-2.2). Pilot 4 briefed the rest of the flight on the Notices to Airmen (NOTAMS) as well as the current weather (Tab V-1.21). Additionally, the brief covered the additional risk factor of having several high profile figures present at the airshow, to include the Chief of Staff of the Air Force (CSAF), and the President of the United States (POTUS) (Tab V-2.8). The ORM sheet was completed by the MP (Tab V-1.14). Fatigue, terrain, and high pressure altitude were identified as items that would increase the risk of the sortie (Tabs V-1.11-1.12, V-1.14, V-2.8, V-7.1, and AA-4).

c. Preflight

The flight plan was filed (Tab K-2 to K-3). The flyby timing was interrupted but did not result in any “cutting of corners whatsoever” (Tab V-1.22). After engine start, the MP conducts the required preflight checks IAW Technical Order (TO) 1F-16CM-1 procedures (Tabs V-1.16 and BB-2-3). The MP could not recall whether or not he conducted the throttle cutoff release (also referred to as a throttle trigger, trigger switch, pinky trigger, pinky switch, throttle cutoff release

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO

trigger switch, lever) portion of preflight check but noted it was in his “habit pattern” (Tab V-1.16). Note: The TO for the F-16CM applies to tail number 92-3890, even though it is designated as an F-16CJ (Tabs V-1.16, BB-2). The TO (Dash 1) throttle cutoff release check instructs the pilot to attempt to fully rotate the throttle outboard and pull the throttle aft to the cutoff position without actuating (physically depressing, squeezing, pulling) the throttle trigger (Tabs Z-14, BB-3, BB-4, and GG-2). This procedure identifies a throttle trigger that is already stuck in the actuated position, but does not identify future sticking/binding of the throttle trigger (Tabs BB 3-4). If during the check, the pilot is able to bring the throttle aft to the cutoff position without actuating the trigger switch, the pilot is instructed to leave the throttle in the cutoff position and notify maintenance (Tab BB-4).

The only other reference in the Dash 1 to throttle trigger actuation is with regard to engine shutdown procedures, “At IDLE, a cutoff release at the base of the throttle must be actuated to allow the throttle to be rotated outboard and retarded to OFF” (BB-3).

d. Summary of Accident

The MF was delayed on the ground approximately 20 to 25 minutes after engine start due to longer-than-expected graduation proceedings (Tab V-2.4). Since the MF was still on the ground, the amount of fuel consumed was negligible (Tab V-2.4). Takeoff occurred around 12:04L (Tab EE-5).

Flyby timing was coordinated with Pilot 7, who was the safety observer and located near on a hill near the stadium. (Tabs V-1.11 and V-8.1). After the flyby, the airshow proceeded without incident (Tabs V-1.23 and V-2.4). The terrain around the show site was described as “difficult” with sloping terrain (Tabs V-1.12, V-1.23, and V-7.1).

The MF flew IAW with USAFADS standard procedure for a visual flight rules landing pattern with all six aircraft in close formation flying over the runway of intended landing at a low altitude before individually and sequentially turning 180 degrees and climbing to parallel the runway on the downwind leg and prepare the aircraft for landing (Tabs BB-29 to BB-31, V-2.4, and V-7.1).

The MP was the last to ascend and turn onto the downwind leg (parallel to and opposing the landing runway, where the pilot typically configures the aircraft for landing) with 1,000 to 1,100 pounds of fuel remaining, 3,000 feet behind Pilot 5 (Tab V-1.2). Thunderbird procedure on downwind includes turning off the display smoke when abeam the approach end of the runway (Tabs V-1.2 and V-7.1).

At 12:59:38L, the Data Acquisition System (DAS) recorded the initial throttle movement to the cutoff position (Tabs EE-12 and EE-29). The throttle had been previously positioned at the idle position (lowest selectable power setting above engine cutoff) for approximately 15 seconds prior to the initial movement to cutoff position (Tabs V-13.3 and EE-42). The MP stated, “I remember pulling my hand back to get to slow down” and then after that movement “I remember feeling something that didn’t feel right” (Tab V-1.3). However, the MP did not recall if he had actuated the throttle trigger or rotated the throttle grip (Tab V-1.15). To place the throttle to the cutoff position, the pilot must normally squeeze the throttle trigger to allow the throttle grip to fully rotate outboard before it can be pulled aft over the idle cutoff stop (Tabs Z-14, BB-3, BB-4, EE-24). The

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO

MP stated that the throttle trigger is “obviously a switch that is very important and is one that we, again, from day one are trained to avoid via hand placement and being deliberate” (Tabs V-1.15 to V-1.16). The MA was established at 222 knots, 2,045 feet AGL, abeam the approach end of Runway 35R when the throttle was first placed to the cutoff position (Tabs V-1.3, V-1.25 and EE-12). Placing the throttle to cutoff cuts ignition and fuel flow, causing the engine to shutdown (Tab BB-3).

At the initial placement of the throttle to the cutoff position (1st Cutoff), the MA was at too low an energy state (a combination of airspeed and altitude) for engine restart prior to ground impact (Tabs BB-6 and EE-29). If an aircraft is at an altitude between 4,000 and 10,000 feet AGL (MP was at approximately 2000 AGL), there is probably time for one airstart prior to minimum recommended ejection altitude (Tabs BB-5 and EE-29). Additionally, at this first movement of the throttle to cutoff, the MA was already at too low an energy state to glide to the runway (Tabs V-1.7 and BB-11 to BB-12). At 12:59:44L, due to RPM decreasing below idle, the MP exercised efforts to restart the engine (Tabs V-1.4 and EE-13). IAW airstart procedures, he intentionally placed the throttle to cutoff (2nd Cutoff) (Tabs V-1.3, V-1.4, V-1.23, V-1.24, BB-9, and EE-13). To restart a failed engine (Pratt & Whitney 229) in flight, the throttle must be placed to cutoff position, then placed midrange, followed by actuation of the Jet Fuel Starter (JFS) (Tab BB-9). While executing those Critical Action Procedures (CAPs), the MP recalled “there was no hang ups on the hump [idle cutoff stop] or anything like that” in reference to moving the throttle to the cutoff position the first time, and “I don’t remember if there was anything weird about the lever [throttle trigger]” in reference to trigger switch actuation, though admitting that the throttle trigger was not the focus of his attention at the time (Tabs V-1.23 to V-1.24).

The MP made a radio call over the interflight frequency stating he had a problem (Tab V-7.1). Pilot 5 had started the final turn and visually acquired the MA, assessing that the MA appeared slower and lower than usual (Tab V-7.1). At 12:59:47L the Emergency Power Unit (EPU) had automatically activated and spun up to the operating range, providing the MA with the electrical power and hydraulic pressure needed to operate its flight controls (Tab EE-13). At 12:59:52L the MP activated the JFS by placing the JFS switch to the START 2 position, providing additional airflow to increase RPM and assist in the airstart (Tab EE-13). At approximately 12:59:53L, the MP made a radio call on Peterson AFB Tower’s radio frequency describing that the engine had cycled off and on, and that he was steering it away from houses and “getting out” (Tab N-3). Pilot 1 then immediately directed Pilot 4 to go-around, which meant Pilot 4 would discontinue his landing approach (Tab V-2.5). At 12:59:59L, the MP moved the throttle slightly above idle (Tabs V-1.3 and EE-13). The MP recalled perceiving the “hump” that indicates movement from cutoff position to idle when he moved the throttle forward (Tab V-1.3). Checking the engine Revolutions Per Minute (RPM) gauge, the MP saw the “RPM gauge decreasing as if it’s failing,” and additionally perceived reduced engine noise (Tab V-1.3). The MP states multiple times that he was initially confused about whether or not he had truly pulled the throttle to the cutoff position (Tabs V-1.3 to V-1.4). At 13:00:03L, the throttle in the MA was placed in and out of cutoff a third time (3rd cutoff), as the MP perceived the airstart was not progressing as he’d hoped (Tabs V-1.17 and EE-13). The MP began a turn to the right, anticipating that if the engine restarted, he might “get just enough thrust to make it to the runway” (Tab V-1.24).

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO

See Figure 1 (below), for a visual depiction of the MA's engine systems for approximately the last minute and a half prior to impact (Tab EE-15). The blue data points ["Thrott Angle (EPLA) deg"] indicate throttle placement fore and aft in angular degrees, with lower numbers meaning a throttle position further aft, and vice versa (Tab EE-15). At lines "1st Cutoff", "2nd Cutoff" and "3rd Cutoff", the blue data points go below "0", showing that the throttle was pulled aft to the cutoff position (Tab EE-15).

The dark red data points, ("Eng N2 Core %RPM"), show the RPM of the engine as a percentage, with a higher percentage meaning greater thrust (~70 - ~80% RPM indicates idle thrust) (Tabs V-1.3, EE-15). After the line noted as "1st Cutoff", the RPM drops rapidly, representative of an engine shutdown (Tabs BB-8 and EE-15). The red data points begin to stabilize just prior to the line labeled "3rd Cutoff", indicating an engine beginning to restart (Tabs BB-6, BB-7, and EE-15). The increasing RPM after "3rd Cutoff" is indicative of an engine in the process of restarting; however, the engine would not have regained usable thrust, prior to ground impact (Tabs BB-5 to, BB-7, and EE-13).

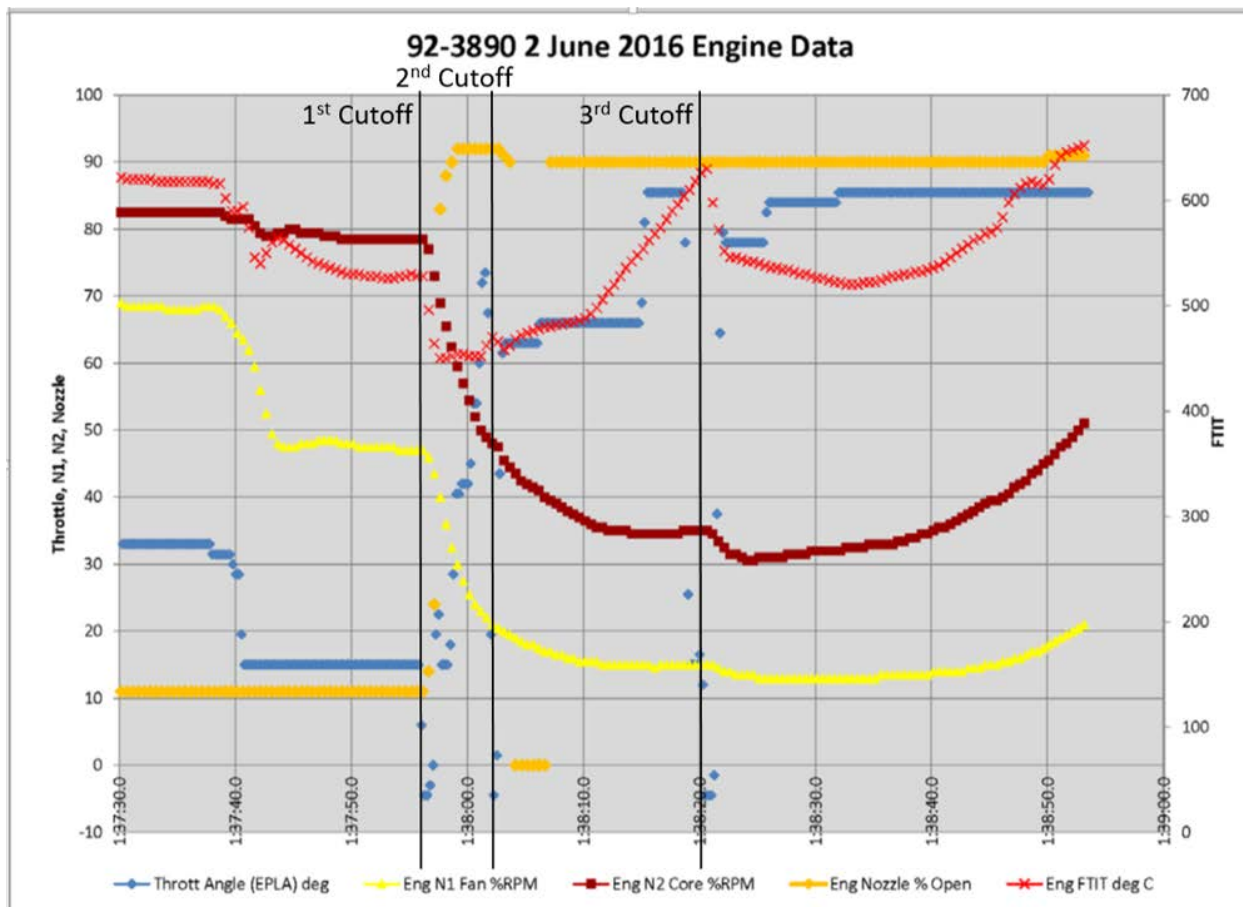


Figure 1: MA Engine Data (Tab EE-15)

The MP continued his turn to avoid houses (Tab V-1.25). At 13:00:28L, the MP ejected at an altitude of 270 feet AGL and airspeed of 149 knots (Tab EE-14). The MP deliberately chose to delay ejection below the minimum recommended ejection altitude specified in the Dash 1 (Tabs

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO

V-1.18 and V-2.5). The MP stated that, at first, he hoped to get the engine restarted quickly even though his airspeed and altitude were below the minimum required for an airstart (Tabs V-1.24 and BB-6). Once the MP realized a quick restart would not occur, he stayed with the MA to maneuver it to an open field (Tab V-1.24 and Z-15). Both Pilot 4 and Pilot 5 observed the MP ejection, and Pilot 5 made a radio call over the interflight frequency that he observed the MP was under a good (successful) parachute (Tabs V-7.1 and V-9.1). Pilot 4 established the airborne on scene command for the pending search and rescue effort (Tab V-9.1).

Figure 2 (below) depicts the final moments of the MA flight path from a satellite view (Tab EE-8). The MA began the 180 degree turn to parallel the runway, flying back to the approach end of Runway 35R (Tab EE-8). Once the MA completed the turn and climbed to the appropriate altitude, it was established southbound on the downwind leg (Tab EE-8). Abeam the approach end of Runway 35R, the MA experienced the first movement to the cutoff position, designated in Figure 2 as “1st Cutoff” (Tab EE-8). Figure 2 depicts aircraft continuation on its downwind heading, to include the second movement to cutoff (“2nd Cutoff”), the activation of the JFS (“JFS Start 2”), and a third movement to cutoff (“3rd Cutoff”) (Tab EE-8). The MP started a right-hand turn just after the 3rd Cutoff ejecting at the position labeled “Canopy Open” (Tab EE-8). The MA impacted at the position labeled “Initial Impact” (Tab EE-8).

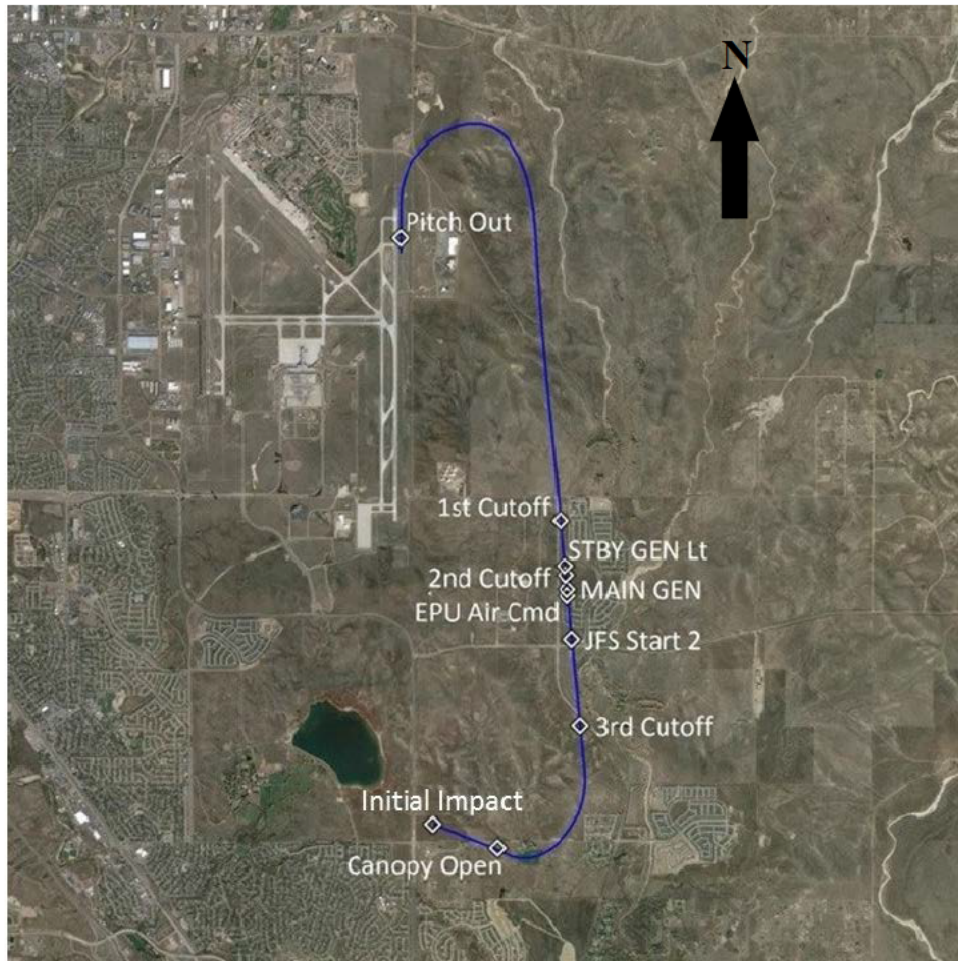


Figure 2: MA Ground Track (Tab EE-8)

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO

e. Impact

The MA impacted the ground at 13:00:36L in an open grassy field, off-base (Tabs Q-5, S-2, EE-6, and EE-14). The MA impacted at relatively wings level, slightly nose high, and came to rest 1,240 feet from initial impact on a slight uphill slope (Tabs S-2, EE-6 and EE-9). The MP's parachute was found 1,450 feet southeast from the initial impact point (Tabs EE-6 to EE-7). The impact area was two miles south of Runway 35R at Peterson AFB, and just to the north of a residential area (Tabs S-2 and EE-8). Figure 3 shows the impact area and Figure 4 shows the aircraft after impact (Tab S-2).

The MA carried no weapons, tanks, or pods (Tab EE-6). After impact, Pilot 1 and Air Traffic Control (ATC) coordinated with a Colorado Army National Guard (COARNG) HH-60 helicopter from the 2nd Battalion, 135th Aviation Regiment to engage in a recovery mission of the pilot (Tab V-1.28 and Tab Z-11).

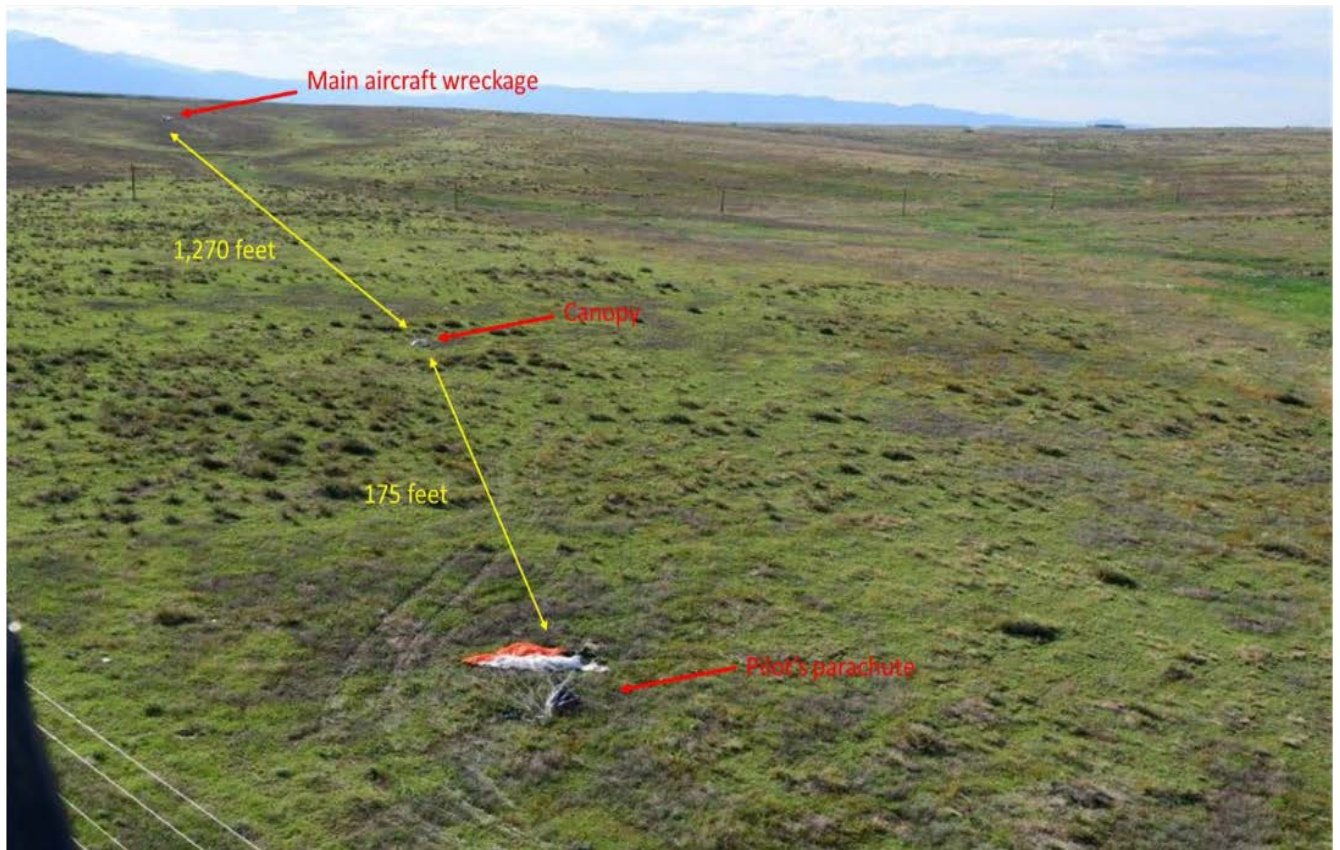


Figure 3: MA Crash Site Looking Northwest. (Tab S-4)

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO



Figure 4: MA post impact (Tab S-2)

f. Egress and Aircrew Flight Equipment

At the initiation of ejection, the seat mounted Digital Recover Sequencer (DRS) selected a Mode I ejection sequence (Tab H-6). The Mode I ejection sequence is for speeds less than 250 +/- 25 knots equivalent air speed and for altitudes from 0 - 15,000 feet Mean Sea Level (MSL) (Tab H-3). Analysis of the canopy, ejection seat, and cockpit systems indicate the ejection event was fully successful, and that the DRS properly selected a Mode I ejection (Tabs H-3 to H-8). There were no overdue inspections that needed to be accomplished on AFE equipment (which includes the egress system) (Tab H-10). The MP was current and qualified in Aircrew Flight Equipment (AFE) continuation training, and all AFE personnel were qualified on the equipment prior to the mishap (Tab H-10). After the mishap, the egress equipment was recovered and sent to Peterson AFB for evaluation, which determined "all subsystems functioned as designed" (Tabs H-2 and H-5).

g. Search and Rescue (SAR)

The MP made the radio call that he would be ejecting from the MA at 12:59:53L (Tabs N-3 and V-2.5). Pilot 1 immediately directed Pilot 4 to "go around" due to Pilot 4 having the most fuel remaining (Tab V-9.1). The MP ejected at 13:00:28L (Tab EE-14). Pilot 4 and Pilot 5 (from the final turn to land) witnessed a good parachute from the MP (Tabs V-7.1 and V-9.1). Pilot 1 coordinated with ATC to send a COARNG HH-60 helicopter to the crash site to pick up the MP (Tabs V-1.27, V-2.5, and Z-11). The MP stated that almost immediately after the ejection, an off-duty firefighter arrived and assumed the role of incident commander (Tab V-1.27). The MP was then evaluated by an off-duty nurse and subsequently by a local ambulance (Tabs V-1.26 to V-1.27). The Peterson AFB fire department initiated incident response 13:06:46L (Tab DD-2). A

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO

command vehicle, a P-34 Rapid Intervention Vehicle (RIV), a P-19 Striker Aircraft Rescue and Firefighting (ARFF) vehicle, a tanker, and a P-22 fire engine were the original response vehicles (Tab DD-8). They responded to the south end of Runway 35R in search of the downed aircraft, knowing only that the pilot had ejected approximately “five miles south” of 35R (Tab DD-8). After finding nothing at the end of the runway, the Command Vehicle and the RIV proceeded south on Power Boulevard (Blvd) while the other vehicles remained for POTUS support (Tab DD-8). An Emergency Operations Center was activated at 13:17:41L (Tab DD-2). At 13:23L, Peterson Airfield Management and Operations (AMOPS) was notified that the COARNG helicopter was on the ground with the MP (Tabs V-1.27, Z-11 and DD-9). The fire department obtained “eyes on” the aircraft at 13:27:56L (Tab DD-2). The aircraft was located in a field near the intersection of Powers Blvd and Fontaine Blvd (Tab DD-8). Security Fire Department, a locally based department, was on scene, and had firefighters approaching the aircraft when the Peterson Fire Department made contact with their Incident Commander (Tab DD-8). Security Fire Department firefighters were recalled and decontaminated for possible hydrazine exposure, and a 1,350 feet “hot zone” was established (Tab DD-8). The Peterson Fire Department notes at 13:30:31L that the pilot “had been removed” (Tab DD-3). AMOPS reported the helicopter had landed at Peterson AFB with the MP at 13:32L (Tab DD-9). After landing, the MP was escorted to an ambulance where he met his flight doctor (Tab V-1.28). Once the hydrazine tank had been removed from the MA, the scene was considered safe (Tab DD-8). The Fire Department terminated the incident at 19:23L (Tab DD-2).

h. Recovery of Remains

Not applicable.

5. MAINTENANCE

a. Aircraft Forms & Documentation

The Air Force Technical Order (AFTO) 781 series of forms collectively document maintenance actions, inspections, servicing, configurations, status, and flight activities (Tab BB-45). The Integrated Maintenance Data Systems (IMDS) is a comprehensive database used to track maintenance actions, flight activity, and to schedule future maintenance (Tab BB-46).

Review of the active AFTO 781 forms and IMDS revealed no overdue inspections or overdue Time Compliance Technical Orders (TCTOs) that would ground the MA from flight operations (Tabs D-13 to D-15). Review of IMDS data for the MA covering a 30-day period prior to the mishap revealed maintenance documentation was properly accomplished under applicable maintenance directives (Tabs U-129 to U-161).

b. Inspections

The Pre-Flight Inspection (PR) and Basic Post-Flight Inspection (BPO) include visually examining the aerospace vehicle and operationally checking certain systems and components “to ensure no serious defects or malfunctions exist” (Tab BB-48). Phase inspections are a thorough inspection of the entire aerospace vehicle (Tab BB-47). Walk-Around Inspections (WAI) are an abbreviated PR Inspection and are completed as required prior to launch IAW the applicable TO (Tab BB-49).

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO

The total airframe operating time of the MA at takeoff of the mishap sortie was 5,481.3 hours (Tabs D-2, D-11). The MA had flown 81.4 hours since its last phase inspection, which was completed on 1 March 2016 (Tab D-2). The last PR inspection occurred on 31 May 2016 at 12:30L with no discrepancies noted (Tab D-5). A WAI occurred on 2 June 2016 at 08:45L with no discrepancies noted (Tab D-5).

Prior to the mishap, the MA had no relevant reportable maintenance issues and inspections were satisfactorily completed (Tabs D-5, D-8, and D-9).

c. Maintenance Procedures

A review of the MA active and historical AFTO 781 series forms and IMDS revealed all maintenance actions complied with standard approved maintenance procedures and TOs (Tabs D-5 to D-11 and BB-45).

In analysis of the throttle trigger, AFRL reported that misalignment of the clevis pin in the bushing could account for the throttle trigger sticking in the retracted position (Tab FF-9).

During replacement of the throttle trigger, alignment of the throttle trigger clevis pin is critical (Tabs V-4.3 and FF-7). Washer placement directly affects throttle trigger clevis pin alignment (Tabs V-4.3 and FF-7). The throttle trigger is a safety mechanism preventing full outboard rotation of the throttle grip (Tab FF-6). There is a discrepancy between the TOs for installing the throttle trigger -- specifically in the number of washers required and placement of the washers (Tabs V-10.1, BB-39, and BB-42). In Chapter 94-61-17, Forward Throttle Grip Assembly, 9461A1, Removal and Installation of TO 1F-16CJ-2-94JG-60-2 (-94JG TO), Step 15 states "one or two washers may be installed with [throttle] trigger depending on allowable clearance" (Tab BB-42). The fault isolation steps of TO 1F-16CJ-2-70FI-00-21(-70FI) state "up to three washers may be installed with [throttle] trigger, depending on allowable clearance" (Tab BB-39). Additionally, the second bullet of the -94JG TO chapter states a washer "shall be installed on the side of the [throttle] trigger that provides best alignment of the clevis pin with clevis pin slot" (Tab BB-42). However, the -70FI TO directs "If only one washer is required, it shall be installed on top side of the [throttle] trigger" (Tab BB-39).

There is no guidance in either the PR/BPO Inspections or the 50-hour Forward Throttle Quadrant (assembly) Inspection to check for alignment of the clevis pin (Tabs BB-37, BB-40). Furthermore, "best alignment" as described by a maintenance member was "trial and error" since the -94JG TO Chapter 94-61-17 refers only to allowable clearances for spacing between the throttle trigger and the throttle grip (Tab V-6.3). There is no mention of a check for the alignment of the clevis pin (to include paint wear) in the PR/BPO Inspections or 50-hour Forward Throttle Quadrant Inspection, but this does not necessarily equate to best alignment (Tabs BB-37, BB-40, and FF-9). There is no mention of a check for debris in or around the throttle trigger clevis pin/bushing (Tabs BB-37 and BB-40).

TO 1F-16CJ-6WC-1 (-6WC) governing PR/BPO Inspections and -70FI 50-hour Forward Throttle Quadrant Inspection procedures to identify a sticking or binding throttle trigger lack sufficient detail (Tabs BB-37 and BB-40). Both the -6WC and the -70FI state "check throttle trigger for sticking or binding" without further guidance on how to perform the check (Tabs BB-37 and BB-

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO

40). Inadequate TO guidance is reflected in the maintenance members' testimony (Tab BB-37 and BB-40). Due to the lack of detail in the TOs, maintenance members' testimony reveal techniques to check for a sticking or binding throttle trigger varied in the number of actuations ("ten" for one person, "eight to ten" for another, or "cycle it as many times as you feel necessary to ensure it is not binding") (Tabs V-10.1, V-11.1, and V-12.5). Maintenance personnel did not check for throttle trigger clevis pin alignment in the bushing since the TO does not reference a check for the alignment during the inspection (Tab BB-37 and BB-40). Based on maintenance member testimony, the throttle trigger did not stick or bind during the preflight inspection done on 31 May 2016 (Tab V-10.1).

The AFRL chemical analysis on the throttle trigger, clevis pin and bushing revealed lubricant/the compound molybdenum disulfide. (Tab FF-8 to FF-9). AFRL could not determine when this lubrication was applied to the throttle trigger assembly (Tab FF-9). The TOs do not direct or prescribe the use of any lubricating compound on the throttle trigger, clevis pin and clevis bushing (Tabs BB-37, BB-39, BB-42, and BB-101). No maintenance member interviewed stated that lubrication would be used on the throttle trigger or clevis pin or bushing as it would be a deviation from TO guidance (Tabs V-10.1, V-11.1, V-12.4, V-5.4, and EE-27).

AFRL analysis suggests the possibility that even with the pass of the on-time 50-hour Forward Throttle Quadrant Inspection and the PR/BPO Inspections, a sticking or binding throttle trigger could occur during the flight (Tab FF-9). Based on LM's analysis of the initial photographs of the MA, they determined the throttle trigger was stuck (actuated); however, they could not determine at what point this occurred (Tab EE-28).

d. Maintenance Personnel and Supervision

The USAFADS Maintenance Team performed all required inspections, documentations, and servicing for the MA prior to flight (Tabs D-5 to D-11, V-5.2, V-5.5, and V-10.1). A detailed review of maintenance activities and documentation revealed no errors (Tabs U-129 to U-161). Personnel involved with the MA's preparation for flight had the proper and adequate training, experience, expertise, and supervision to perform their assigned tasks (Tabs T-6, T-7, T-9 to T-10, and V-10.1).

e. Fuel, Hydraulic, and Oil Inspection Analyses

Samples from both the fuel trucks and hydraulic oil cart were taken prior to the mishap sortie on 2 June 2016 (Tab U-2). The 99th Logistics Readiness Squadron's Fuel Laboratory at Nellis AFB, NV analyzed those samples and did not report any volatile contamination in either the fuel servicing vehicles or the hydraulic oil servicing cart (Tab U-3). According to the Lockheed Martin (LM) analysis the DAS showed fuel was available to the engine throughout the recorded data up to ground impact (Tab EE-35). Additionally, a photo of the wreckage cockpit (see Figure 5 below) showed the fuel gauge indicator at approximately 900 pounds of fuel (Tab Z-13). Finally, the LM analysis shows the hydraulic and engine oil systems maintained within the normal operating limits until the MA's impact (Tab EE-34).

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO



Figure 5. Fuel gauge for the MA indicating approximately 900 pounds of fuel in the fuel tanks after impact (Tab Z-13)

f. Unscheduled Maintenance

The MA had six deferred, unscheduled unrelated discrepancies in the active forms over the previous 90 days (Tab U-162). The Exceptional Release for the MA was completed and the aircraft was deemed airworthy (Tab D-5). The Production Superintendent or higher reviews and signs the Exceptional Release in the forms to certify that the aerospace vehicle is safe for flight. (Tab BB-51).

6. AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS

a. Structures and Systems

The MA impacted the ground (grass field) wings level from a relatively level attitude (Tabs S-2 and EE-9). All of the MA debris was contained within a narrow trajectory from the point of impact to the point of resting, an approximate distance of 1,240 feet (Figure 6, Tabs S-4 and EE-6 to EE-7). Most of the sustained damage was on the undercarriage of the MA due to its low-angle flight path upon impact (Tabs Z-3, Z-2, EE-9, and EE-37 to EE-38).

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO



Figure 6. Photo of grassy field indicating impact area, narrow debris field, and MA at rest position (Tab Z-12)

(1) MA Fuselage

The forward fuselage module (nosecone) sustained damage upon impact and separated from the aircraft (Figure 7, Tab Z-2). The cockpit structure sustained damage upon impact and was partially separated just forward of center fuselage (Figure 8, Tab Z-4). The engine intake module sustained damage upon impact (Figure 9, Tab Z-5). The right main landing gear was twisted and bent rearward after the landing bay doors were torn from the undercarriage (Tab EE-37). The aft engine access cover sustained damage and was found in the debris trail (Figures 10 and 11, Tab Z-6).



Figure 7. Front view (looking aft) of MA showing damage to cockpit and right and left wings (Tab Z-2)

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO



Figure 8. Left view of MA showing partial cockpit separation and damage to tail section of engine bay (Tab Z-3)



Figure 9. MA Engine intake and cockpit (Tab Z-4)



Figure 10. MA Engine bay access cover in debris field (Tab Z-6)

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO



Figure 11. MA Right aft tail section under speedbrake (looking forward) (Tab Z-7)

(2) MA Flight Control Surfaces

All of the control surfaces remained attached to the MA after impact (Figures 12 and 13, Tabs Z-3, Z-4, and EE-37). The left and right wing tip sustained damage after impact (Figure 13, Tab EE-38). Based on the DAS, the MA flight control system was responding properly to inputs until impact (Tab EE-38).



Figure 12. MA Left horizontal stab damage (Tab Z-8)

(3) MA Horizontal Stabilizer

The left horizontal stabilizer sustained damage from impact but remained attached to the aft portion of the fuselage, while approximately half of the outer portion of the right horizontal stabilizer had detached (Tabs Z-9 and EE-38).

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO



Figure 13. Photo showing damage to MA right horizontal stab, right and left wing tips (Tab Z-9)

(4) MA Engine

The lower portion of the engine and engine exhaust sustained damage from impact (Figures 14 and 15, Tabs Z-4, Z-5, Z-6, Z-7, and Z-10). The engine was operating and responding as expected until the point of impact (Tab EE-31).



Figure 14. Damage to MA engine intake (Tab Z-5)



Figure 15. Damage to MA engine exhaust (Tab Z-10)

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO

(5) MA Canopy

The canopy sustained damage after ejection from the aircraft (Tab S-3). The canopy was found approximately 1,270 feet southwest from the initial impact point (Figure 16, Tab S-4).



Figure 16. Photo of MA canopy (Tab S-3)

b. Evaluation and Analysis

(1) DAS

The DAS includes the ECSMU, which contains non-volatile memory (Tab EE-9). The Enhanced Crash Survivable Memory Unit (ECSMU) houses crash-protected, non-volatile memory that contains flight data such as analog inputs, discrete inputs, and message data (Tab EE-9). Data is recorded at the time power from the battery is initiated at engine startup and ends when the power from the battery is turned off (Tab EE-9). The DAS operated as expected until impact of the MA (Tab EE-11).

(2) Major Aircraft Systems

AFRL analysis of the ECSMU was operating as designed (Tab EE-11). The ECSMU data revealed major aircraft systems (flight control surfaces, engine, electrical, fuel, hydraulic, JFS, and EPU systems) were performing as expected for the duration of the MA's flight and prior to impact (Tabs EE-9 to EE-23 and EE-31). Data also revealed the MP brought the throttle to idle approximately 40 times during the MA's flight without reaching engine cutoff position (Tab V-13.3). For the approximate 15 seconds prior to the first time the throttle was placed to cutoff position, the throttle was in idle (Tab V-13.3). Analysis of the recorded flight data from the ECSMU was consistent with the MP's recollection of events (Tabs V-1.3 to 1.4 and EE-12 to EE-16).

(3) Throttle Control Assembly

Since all systems were operating as expected, further analysis was done by AFRL on the throttle control assembly and its components since the throttle trigger was discovered in the actuated (stuck/retracted) position (Tab EE-26). A properly functioning throttle trigger prevents engine cutoff by preventing full throttle grip rotation (counterclockwise, aft looking forward) unless the throttle trigger clevis pin is retracted (Tab FF-6). Based on the initial photographs the throttle trigger was found stuck (actuated); however, LM Aero could not determine when the throttle

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO

trigger became stuck in the MA (Tab EE-28). PR/BPO Inspections include actuating the throttle trigger to ensure the pin does not stick in the retracted position (Tab FF-6).

Initial inspection of the throttle grip revealed an incorrect placement of a washer on top of the throttle grip assembly where the throttle trigger pin is inserted (Tabs BB-42, BB-43, and EE-26). However, additional analysis concluded this incorrectly placed washer did not affect alignment of the throttle trigger clevis pin or clearances allowed in the TO (Tabs V-13.2, FF-9). Conversely, paint wear between the throttle trigger and the mounted surfaces were slightly outside of allowed TO tolerances and did affect the alignment of the throttle trigger clevis pin (Tab FF-9).

(4) Throttle Trigger

The PR/BPO Inspections include actuating the throttle trigger to ensure no sticking or binding occurs (Tabs BB-37, FF-10). The throttle trigger is a spring-force safety mechanism positioned on the throttle grip (see Figure 21) that, when operating properly, prevents inadvertent, full rotation of the throttle grip to a cutoff position (Tabs EE-25 and FF-5). The throttle trigger must be physically actuated (pulled, depressed, squeezed) to overcome the spring-force in its un-actuated position (Tabs Z-14, EE-25, EE-26, FF-7, and GG-2). The throttle when pulled rearward hits the idle cutoff stop, which is the engine idle position and before engine cutoff position (Tab EE-25). To overcome the cutoff stop and reach the throttle cutoff position, the throttle trigger must first be actuated followed by an outward rotation of the throttle grip (Tab EE-26). There is no history of reaching engine cutoff position without application of full outboard rotation of the throttle grip (Tabs V-4.2, V-13.3, and Z-14). A significant number of sticky throttle triggers in F-16 history have led to hardware changes that have reduced but not eliminated the number of occurrences (Tab EE-28).

Additionally, F-16s undergo an inspection of the forward throttle quadrant every 50 hours (Tab BB-40, FF-6) that includes checking the throttle trigger for sticking or binding, measuring the amount of clevis pin retraction into the clevis pin bushing, and checking the clearance between the clevis pin and a shim (spacer) where the clevis pin rests on the throttle quadrant when the throttle trigger is not actuated (Tabs FF-6, and FF-10).

Further in-depth analysis by AFRL was conducted on the throttle trigger's movements and components (Tab FF-8). Upon arrival to AFRL and prior to disassembly of the throttle quadrant, the throttle trigger was actuated seven times without sticking, with the eighth pull (squeeze) resulting in the throttle trigger sticking (Tab FF-7). The throttle trigger became unstuck while gently handling the grip (Tab FF-7). At this point, an official trial was conducted to determine the frequency and degree of a sticking throttle trigger by actuating it 50 times (see Table 1, Tabs FF-7 and FF-23). The degree of sticking was recorded in terms of whether the throttle trigger stuck in the actuated position (red x), whether binding of the mechanism could be felt while the throttle trigger returned itself to the normal position (yellow \), or whether the throttle trigger returned itself to the normal position smoothly (green -) (Tabs FF-7 and F-23). Binding was typically felt after a trial that stuck (Tabs FF-7, FF-23). The combination of sticking and binding frequency of the throttle trigger was 36 percent (24 percent sticking, 12 percent binding) (Tabs FF-7 and FF-23).

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO

| Trial Number | | | | |
|--------------|-------|-------|-------|-------|
| 1-10 | 11-20 | 21-30 | 31-40 | 41-50 |
| x | - | x | x | - |
| x | - | \ | - | - |
| x | - | - | - | - |
| x | - | \ | - | - |
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| x | \ | - | - | - |
| \ | \ | - | - | x |
| - | - | - | - | \ |
| - | - | - | - | - |

x = Stuck retracted

\ = Binding, but returned

- = No sticking or binding

Table 1. Table showing 50 trial for sticking and binding for MA throttle trigger actuations (Tab FF-23)

The bushing was inspected with the throttle trigger clevis pin in the retracted position (Tab FF-8). A significant amount of debris was present within and around the bushing and broken composite fibers protruded from the bushing (Figure 16, Tab FF-8). Debris contamination and damage to the throttle trigger bushing due to throttle trigger clevis pin misalignment (not visible to the naked eye), caused friction between the throttle trigger clevis pin and the throttle trigger bushing (Tab FF-9). The debris was analyzed by electroscopic dispersive spectroscopy and composition was consistent with a mixture of aluminum, steel (consistent with wear debris from throttle lever), dirt, and a lubrication compound (molybdenum disulfide) (Figure 16, Tabs FF-8 and FF-19).

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO

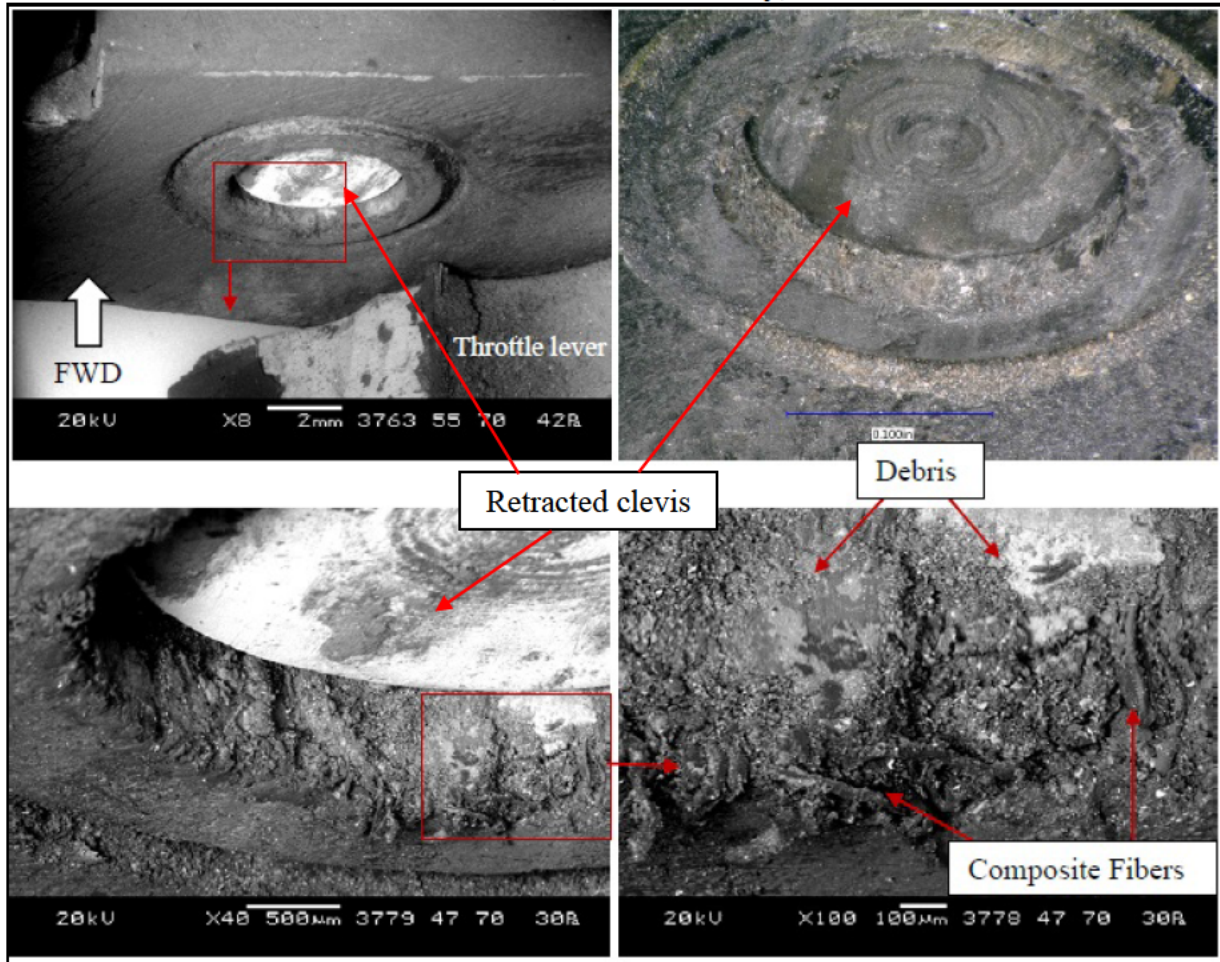


Figure 17. Contamination of the MA's throttle trigger clevis bushing evident with the pin in the retracted position (Tab FF-19)

Transverse cuts of the excised bushing were measured for diameter thickness discrepancies (Tabs FF-8, FF-19, and FF-22). Measurements indicated the alignment of the throttle trigger clevis pin was angularly misaligned causing a thinning of the bushing diameter at the 12 o'clock position near the aft end and 7 o'clock (aft looking forward) position near the forward end (Figure 18, Figure 19, Tabs FF-8 and FF-22.).

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO

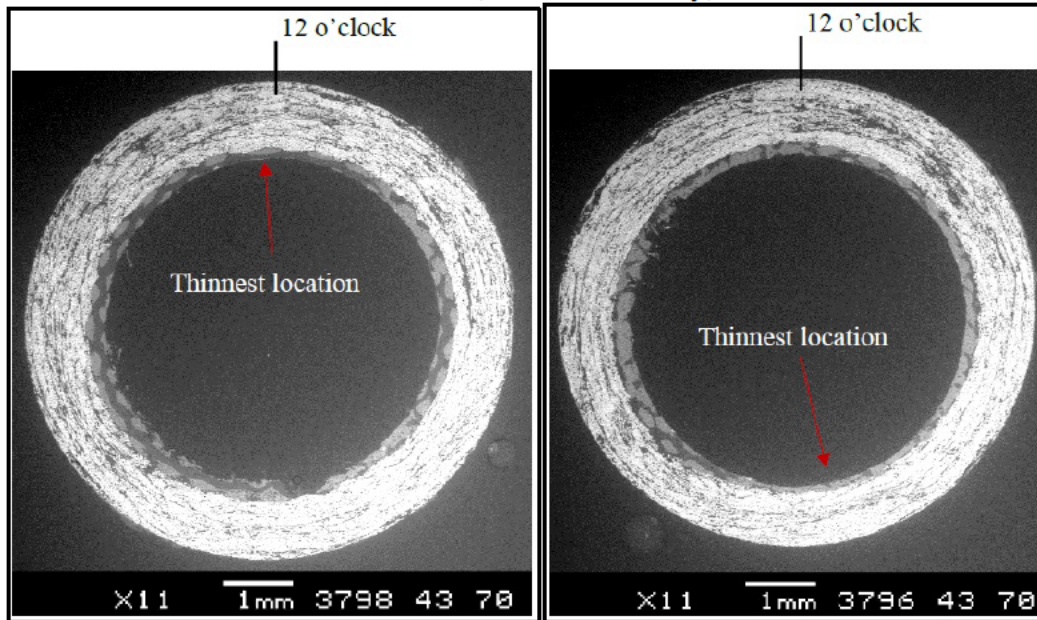


Figure 18. Scanning electron microscope images of the section 0.01 inches from the aft/forward portions of the MA's throttle trigger clevis bushing showing variation in thickness (Tab FF-22).

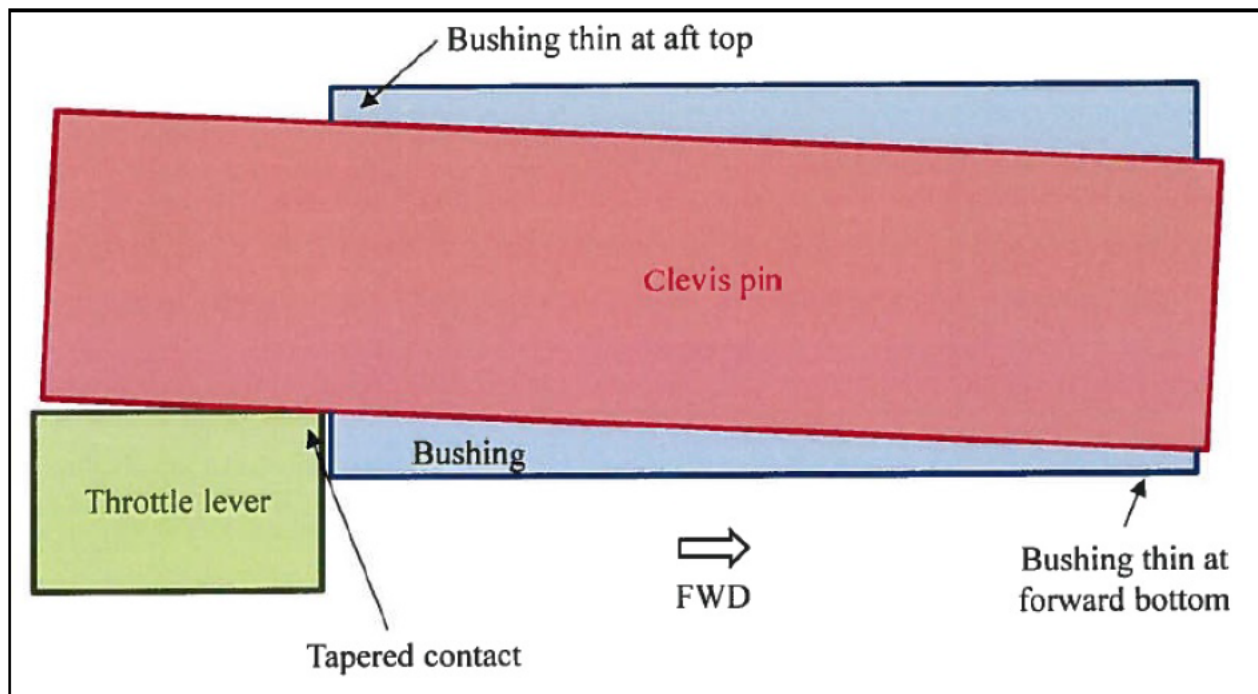


Figure 19. MA Misalignment throttle trigger clevis pin in bushing (Tab FF-22)

The clearance between the throttle trigger and throttle grip at the spring-loaded pivot was beyond tolerance by 0.002 inches (Figure 20, Tab FF-9). Paint wear on four painted interfaces likely resulted in the clearance outside of tolerance range (Figure 21, Tab FF-9). As AFRL noted in their report, the clearance at this location would affect the likelihood for sticking (Tab FF-9).

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO

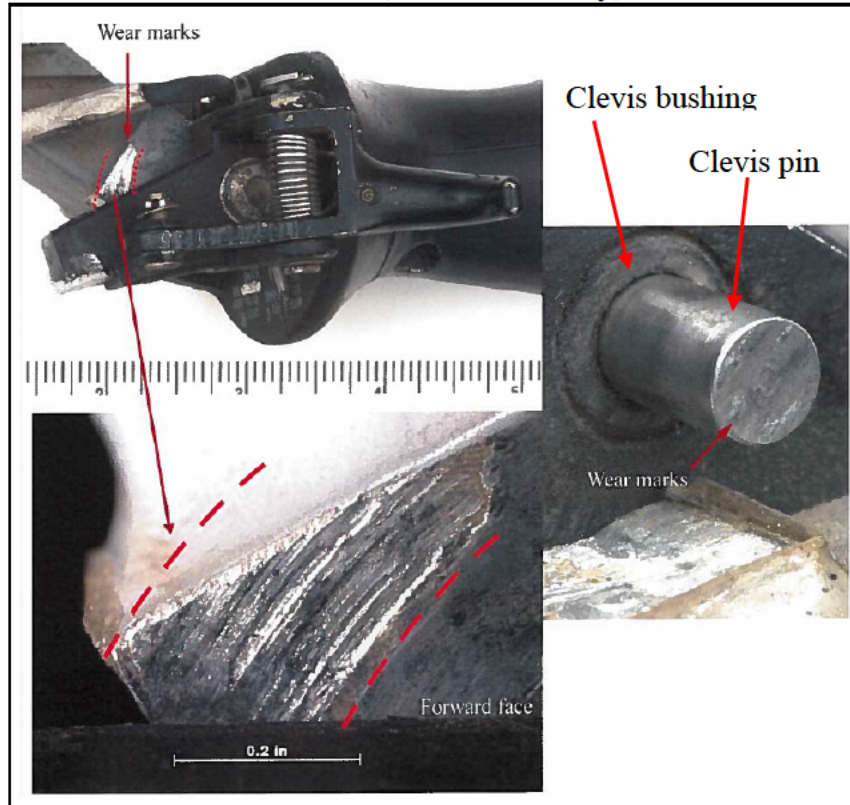


Figure 20. Wear between the MA's clevis pin and forward face of the throttle (Tab FF-16)

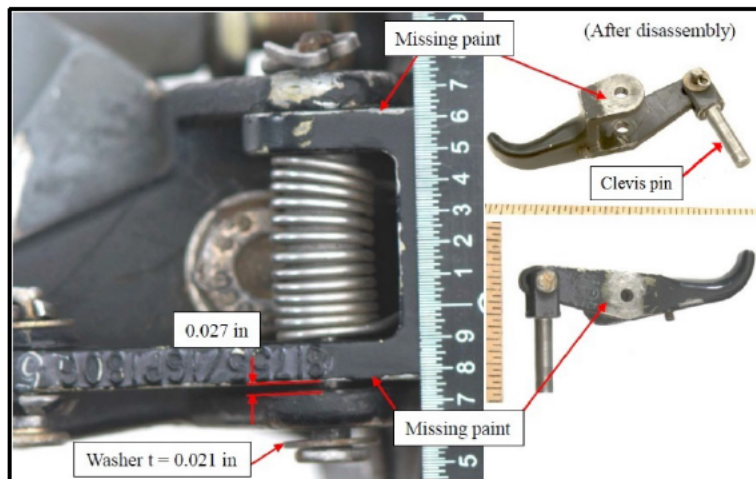


Figure 21. Clearance measurement at the spring-loaded throttle trigger pivot point while assembled, and worn surfaces of the MA throttle trigger observed after disassembly (Tab FF-18)

7. WEATHER

a. Forecast Weather

On 2 June 2016, Pilot 4 briefed the MF forecasted weather for Colorado Springs Airport (Peterson AFB), US Air Force Academy Airfield, and Butts Army Airfield (Fort Carson) (Tabs F-2, V-1.21,

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO

and V-2.2). A second weather update was provided to the MF after the briefing (Tabs F-2 and V-1.21). Colorado Springs reported winds from the southwest at four knots, 10 statute miles of visibility and few clouds at 5,000 feet AGL (Tab F-2). The USAF Academy Airfield reported winds from the northwest at six knots, 10 statute miles of visibility, and no clouds (Tab F-2). There was no precipitation in the forecast for any of the three airfields (Tab F-2).

b. Observed Weather

Colorado Springs provided a special observation on 2 June 2016 at 13:04L, reporting light winds out of the southeast, 10 statute miles of visibility, scattered clouds at 7,000 feet AGL and an altimeter of 30.20 pounds per square inch (Tab F-3). The most recent observation for Colorado Springs prior to the mishap was recorded on 2 June 2016 at 12:54L, and reported winds light and variable, 10 statute miles of visibility, scattered clouds at 6,000 feet AGL, with an altimeter of 30.20 pounds per square inch (Tab F-3). No precipitation was observed at Colorado Springs Airport (Tab F-3).

c. Space Environment

Not Applicable.

d. Operations

The MF was operating within its prescribed weather limits.

8. CREW QUALIFICATIONS

a. USAFADS Pilot Waivers

Due to the unique nature of their mission, the USAFADS maintain a list of waivers to Air Force documents in their Operations Manual, 57WGI 11-USAFADS Volume 3 (Tab BB-15 to BB-17). These waivers are coordinated through the 57 Wing Commander, USAFWC Commander, Headquarters ACC A3, and the COMACC (Tab BB-15). Waivers related to crew qualifications are listed below (Tab BB-15 to BB-17):

“Waiver to Air Force Manual 11-210 (Instrument Refresher Program) requirement that the instrument refresher course be completed every fourth quarter of the calendar year. Rationale: Due to the extensive Thunderbird off station Temporary Duty [TDY] commitments, it is more practical for the team to collectively accomplish the course during training season” (Tab BB-15).

“Waiver to Air Force Instruction (AFI) 11-2F-16V1 requirements for pilots to maintain CMR [Combat Mission Ready]/BMC [Basic Mission Capable]/BAQ [Basic Aircraft Qualification] qualifications. Rationale: Thunderbird specific training and flight demonstrations limit pilot capability to accomplish normal CMR/BMC/BAQ qualifications. Thunderbird pilots will maintain qualifications IAW the Combined Thunderbird Pilot Syllabus and this volume” (Tab BB-15).

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO

“Thunderbird pilots will have their Crew Duty Position upgraded to MP [*Note: different from mishap pilot; this abbreviation “MP” is a two letter designator for qualifications in the F-16*] in the HARM [Host Aviation Resource Management] records and on the Letter of X’s [*a table depicting the various qualifications and currencies of the pilots*] when they complete the TS/AHC [Training Sortie/Advanced Handling Characteristics] portion of their respective flying syllabus. Completion of the portion ensures qualification to accomplish the unit’s Designated Operational Capability [DOC] statements mission. A memorandum will be signed by the USAFADS/CC [Thunderbird Commander] and placed in the student’s gradebook. The USAFADS Training Officer will complete a form AF4324 [aircrew qualification worksheet] updating the crew duty position from FP [a different designator] to MP” (Tab BB-16).

“Waiver to AFI 11-2F-16V2 requirements for Initial Instructor checks. Rationale: Thunderbird instructor pilots [IP] will be selected by the USAFADS/CC based on experience level and previous qualifications. Thunderbird instructor upgrades will be IAW the Combined Thunderbird Pilot Syllabus and will be designated in the gradebooks and on the Letter of X’s, but will not require an Initial Instructor Form-8 [official form used to document flight evaluations]. Included in pilots FEF’s [Flight Evaluation Folder] will be a memorandum that explains the specific instructor duties while on the Thunderbird Team. Current “F-16” IP’s will maintain their qualifications in the HARM records and Letter of X’s, but will not log IP time unless conducting specific F-16 instructor duties” (Tab BB-16).

b. Mishap Pilot

The MP was a current and qualified air demonstration pilot (Tab T-2). He completed Air Force Undergraduate Pilot Training (UPT) at Vance Air Force Base, Oklahoma in June of 2007 (Tab T-3). He remained at Vance AFB for Introduction to Fighter Fundamentals (IFF) and graduated in January of 2008 (Tab T-3). The MP moved to Luke AFB, Arizona for initial qualification in the F-16 from January 2008 to November 2008 (Tab T-3). After completing initial qualification training, the MP moved to Kunsan AB, Republic of Korea from November 2008 to December 2009 (Tab T-3). The MP completed his 4-ship flight lead upgrade prior to departing Kunsan AB (Tab V-1.20). Subsequent duty stations include Spangdahlem AB, Germany from 2010 to 2013, and Hill AFB, Utah from 2013 to 2015 (Tab T-3). The MP completed his Instructor Pilot Upgrade prior to leaving Spangdahlem in 2012 (Tab V-1.20). The MP was a current and qualified F-16 CAF instructor pilot prior to his acceptance into the USAFADS (Tab T-3).

The USAFADS do not conduct mission checkrides (a formal evaluation of flying skill, ability, and safety) as a result of the guidance specified in paragraph 8.a.2) above (Tab R-33). The MP’s last mission checkride was 10 July 2014 (Tab G-7). The MP’s most recent instrument checkride was completed on 23 May 2016, though his Air Force Form 942, Record of Evaluation and Individual Training Summary do not have the completed checkride date notated (Tab G-7 to G-8). In the USAFADS, the MP was current and qualified as an experienced (more than 500 hours in the F-16) Thunderbird flight lead, Operations Supervisor and weather category two pilot (can fly instrument approaches with weather better than or equal to: clouds at 300 feet AGL and visibility of 1 NM) (Tab G-2). His total flight time was 1,447.1 hours, 116 of those hours as an instructor (Tab G-3). The MP was listed as a qualified Range Safety Officer (RSO), however, the RSO upgrade sheet in his gradebook does not reflect the completed upgrade (Tab T-4).

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO

On the day of the mishap, the MP's recent flight time was as follows (Tab G-4):

| MP | Hours | Sorties |
|--------------|-------|---------|
| Last 30 Days | 32.8 | 20 |
| Last 60 Days | 71.2 | 42 |
| Last 90 Days | 102.2 | 72 |

The MP's most recent flight prior to the mishap had been on 31 May 2016 (Tab G-6). The MP recalled last completing a CAPs sheet in May, however Pilot 1 and a copy of the MP's go/no go sheet specify that CAPs were turned in on 1 June 2016 (Tabs V-1.10, V-2.9, and AA-5).

9. MEDICAL

a. Qualifications

The MP was medically qualified for flying duties without restrictions at the time of the mishap (Tab X-2). The MP's most recent annual military Periodic Health Assessment was performed on 3 December 2015 (Tab X-2). The MP's annual dental examination was performed on 23 February 2016 (Tab X-2). His medical records contained a current Air Force Form 2992, Medical Recommendation for Flying or Special Operational Duty, dated 3 December 2015 (Tab X-5). Additionally, MP had no medical waivers in the Aeromedical Information Management Waiver Tracking System (Tab X-4).

The MP's records reflected no recent performance-limiting illness prior to the mishap (Tab X-2).

b. Health

The MP successfully ejected from the aircraft and performed a parachute landing fall, suffering a minor injury (Tab X-2). Local emergency responders recovered the MP and he was transported along with the USAFADS flight surgeon to the local emergency department for further evaluation (Tab V-1.27). He was then brought to the nearest military treatment facility where he was further evaluated in the flight medicine department (Tab V-1.27). Medical history including 72-hour and 14-day history and physical exam were completed, and blood and urine specimens were obtained (Tab X-2).

c. Pathology/Toxicology

Immediately following the mishap and in accordance with safety investigation protocols, blood and urine samples were collected and submitted to the Armed Forces Medical Examiner System at Dover Air Force Base, Delaware for toxicological analysis (Tab X-2). Blood samples for MP were found to be within normal limits for carbon monoxide levels and were negative for ethanol. (Tab X-2). Blood testing for all MA maintenance crewmembers were negative for ethanol (Tab X-2). Urine drug screen testing for MP and all MA maintenance crewmembers were negative for amphetamines, barbiturates, benzodiazepines, cannabinoids, cocaine, opiates, phencyclidine, and sympathomimetic amines by immunoassay or gas chromatography/ full scan-mass spectrometry (Tab X-2).

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO

d. Lifestyle

72-hour and 14-day histories, medical charts, and interviews with the MP as well as the MA maintenance crewmembers, revealed no lifestyle factors relevant to the mishap (Tab X-2 to X-3).

e. Crew Rest and Crew Duty Time

AFI 11-202, Volume 3, General Flight Rules, ACC Supplement, dated 28 November 2012, prescribes mandatory crew rest and maximum Flight Duty Periods for all personnel who operate USAF aircraft. Based on the information provided from 72-hour and 7-day histories, crew rest was adequate and IAW published guidance. (Tabs X-2, BB-93, and BB-95).

10. OPERATIONS AND SUPERVISION

a. Operations

The scheduled hours of work per duty day in combination with the intensity of the work and the number of days worked sequentially (Ops Tempo) for the USAFADS is high, as evidenced by the MP accruing 20 sorties in 30 days (Tabs G-4 and V-2.6). USAFADS Operations personnel describe the Ops Tempo as “busy”, stating that they fly six out of seven days and spend 220 days per year on TDY, or “on the road” (Tabs V-2.6, V-7.1, and V-9.1). The day of the mishap was day eight of a 10 day trip with three separate show sites in three separate time zones (Tabs V-1.10 and V-7.1). Fatigue was identified as an additional factor for the MP; however, the ORM was considered low for the mission (Tabs V-7.1 and Tab AA-4).

The USAFADS pilots conduct Supplementary Emergency Procedure Training (SEPT) primarily by the “tabletop” method, which is a detailed discussion on EPs in an academic environment (Tab V-1.9). The USAFADS pilots have limited access to simulators while TDY and only on specific days can they use the simulators at Nellis AFB (Tabs V-1.9). SEPTs focus on EPs from each phase of flight, takeoff, cruise, enroute, and landing as well as EPs specific to USAFADS operations (Tabs V-1.9, V-1.10, and AA-3).

The general consensus of opinion is the USAFADS Ops Tempo is comparable to other assignments (Tabs V-1.12, V-1.13, V-2.6, and V-7.1). All USAFADS members indicated work days are not as long in the USAFADS as they may be in the CAF, but the TDY schedule and separation from family is the largest source of stress (Tabs V-2.6 and V-7.1).

The USAFADS Maintenance Team members interviewed stated that although they are very busy, they enjoyed their jobs, had adequate time for leave, fitness, and family, and cited a very strong relationship between operations and maintenance personnel to get the team going. (Tabs V-5.5, V-12.5).

b. Supervision

The USAFADS commander did not notice anything out of the ordinary for the members of his flight during the MF (Tab V-2.4).

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO

In addition to a site survey, the USAFADS ensure a safety observer, typically Pilot 7 or 8, is stationed near show center as an additional level of flight supervision (Tabs V-8.1 and BB-21). The safety observer usually holds a dual role as the Supervisor of Flying (SOF), and will station in the control tower for an airfield airshow (Tabs V-8.1 and BB-21). For this USAF Academy airshow, the safety observer was located on a hill above the USAF Academy football stadium (Tab V-8.1). Thus, there was no USAFADS SOF in the Peterson AFB tower, and the safety observer left the primary interflight radio frequency immediately prior to landing due to the inability to hear (reception range) Peterson Tower's radio calls from his USAFA location. (Tab V-8.1).

11. HUMAN FACTORS ANALYSIS

a. Introduction

AFI 91-204, Safety Investigations and Reports, 12 February 2014, Attachment 6, contains the Department of Defense (DoD) Human Factors Analysis and Classification System (HFACS) which lists potential human factors that can play a role in aircraft mishaps (Tab BB-54). Human factors define how interactions with tools, tasks, and working environments systemically influence human performance (BB-54). It is designed for use by an investigation board in order to accurately record all aspects of human performance associated with an individual and the mishap event (Tab BB-54). The DoD HFACS helps investigators perform a more thorough investigation as well as classify particular actions (or inactions) that sustained the mishap sequence (Tab BB-54). The DoD HFACS classification taxonomy divides the failures into active failures and latent failures (Tab BB-54). Active failures, or "Acts," are the actions or inactions of individuals that are believed to cause or contribute to the mishap (Tab BB-55). Latent failures are pre-existing conditions within in an organization that indirectly affect the sequence of mishap events (Tab BB-55). Latent failures or conditions are divided into Preconditions, Supervision, and Organizational Influences (Tab BB-55). The human factors listed below are those that were determined to be relevant to the determination of cause or substantially contributing factors to the mishap.

b. AE101 Inadvertent Operation

A factor when an individual's movements inadvertently activate or deactivate equipment, controls or switches when there is no intent to operate the control or device. This action may be noticed or unnoticed by the individual (BB-60).

There was inadvertent operation when the MP applied outboard rotation to the throttle grip with aft-pressure while the throttle was in the idle position, moving the throttle to the cutoff position (Tab V-1.3 and EE-12).

In order to move the throttle aft to cutoff position, first the throttle cutoff trigger must be actuated permitting full outboard rotation applied to the throttle grip (Tab BB-3). There are no known reported incidences of the F-16 throttle being placed to cutoff position without full throttle grip rotation outboard (Tab V-4.2).

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO

c. OP003 Procedural Guidance/Publications

Procedural Guidance/Publications is a factor when written direction, checklists, graphic depictions, tables, charts or other published guidance is inadequate, misleading, or inappropriate and this creates an unsafe situation (BB-78).

TOs lack sufficient detail to consistently identify either a throttle trigger clevis pin misalignment or a sticking/binding throttle trigger. (*For more information, refer to "Maintenance" paragraph 5.b.2 above*).

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Publicly Available Directives and Publications Relevant to the Mishap

- (1) AFI 51-503 Aerospace and Ground Accident Investigations, dated 14 April 2015
- (2) AFI 51-503 Air Combat Command Supplement Aerospace and Ground Accident Investigations, dated 28 January 2016
- (3) AFI 91-204, Safety Investigations and Reports, Attachment 6, dated 12 February 2014, incorporating Air Force Guidance Memorandum to AFI 91-204, dated 11 January 2016
- (4) AFI 48-123, Medical Evaluations and Standards, dated 5 November 2013
- (5) AFI 11-202 Flying Operations, dated 22 November 2010

NOTICE: All directives and publications listed above are available digitally on the Air Force Departmental Publishing Office website at: <http://www.e-publishing.af.mil>.

b. Other Directives and Publications Relevant to the Mishap

- (1) TO 1F-16CM-1
- (2) 57 WGI 11-USAFADS Volume 3, Flying Operations, dated 1 November 2013
- (3) TO 1F-16CJ-6WC-1
- (4) TO 1F-16CJ-2-70FI-00-21
- (5) TO 00-20-1
- (6) TO 1F-16CJ-2-94JG-60-2
- (7) USAFADS Standard Operating Procedures, dated January 2016
- (8) TO 1F-16CJ-2-76JG-00-1

c. Known or Suspected Deviations from Directives or Publications

None

//Signed//

26 August 2016

BRIAN J. KAMP, Colonel, USAF
President, Accident Investigation Board

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO STATEMENT OF OPINION

**BLOCK 52 F-16CJ, T/N 92-003890
EL PASO COUNTY, CO
2 JUNE 2016**

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

1. OPINION SUMMARY

On 2 June 2016 at 13:00 local time an F-16CJ was destroyed by ground impact after the Mishap Pilot (MP) ejected south of Peterson Air Force Base (AFB), CO. The MP sustained a minor injury and no other personnel were injured. The Mishap Aircraft (MA) Tail Number 92-3890 and the MP are assigned to the 57th Wing, United States Air Force Air Demonstration Squadron (USAFADS), Nellis AFB, NV. The MA, valued at \$29,466,037.00 (total government loss), was destroyed. There was no known damage to civilian property.

I find by a preponderance of the evidence the cause of this mishap was (a) throttle trigger actuation and subsequent malfunction (throttle trigger stuck in retracted position), followed by (b) the MP's inadvertent full-rotation of the throttle grip while retarding the throttle aft to cutoff position. Substantially contributing factors include maintenance Technical Orders (TOs) that lack sufficient detail to consistently identify either a throttle trigger clevis pin misalignment or a sticking/binding throttle trigger.

I developed my opinion by interviewing maintainers of the mishap aircraft, pilots of the mishap flight, as well as operations and maintenance supervisors in person. I also analyzed recorded flight data, reviewed Air Force directives, engineering analysis, and telephonically interviewed technical experts from the F-16 System Program Office (SPO), Air Force Research Laboratory (AFRL), and Lockheed Martin (LM).

2. CAUSE

The cause of this mishap was a throttle trigger actuation and subsequent malfunction (throttle trigger stuck in retracted position) followed by the MP's inadvertent full-rotation of the throttle grip while retarding the throttle aft to cutoff position.

a. Throttle cutoff release actuation and subsequent malfunction

An un-actuated (un-squeezed) throttle trigger on the F-16 throttle grip provides a safeguard, preventing inadvertent full throttle grip rotation outboard. Full throttle grip rotation outboard permits the movement of the throttle to the full aft position (engine cutoff). A malfunctioning throttle trigger (stuck in retracted position) eliminates the safeguard. The throttle trigger was

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO

recovered post-mishap in an actuated (stuck) position. The throttle trigger must be physically actuated (depressed, squeezed, pulled) to overcome the spring-force in its un-actuated resting position. No conclusive evidence identified how or when the throttle trigger was actuated. AFRL/Materials Integrity Branch analyzed the MA throttle trigger. Testing identified intermittent (36%) sticking/binding by the MA throttle trigger. AFRL analysis also indicated debris contamination and damage to the throttle trigger bushing due to throttle trigger clevis pin misalignment, which caused friction between the throttle trigger clevis pin and the throttle trigger bushing. This increased the chance of sticking. In addition, lubricant to the throttle trigger assembly was identified (inconsistent with maintenance technical orders), which exacerbated the debris contamination condition. Thorough research on origin of this lubricant was inconclusive. Historic throttle trigger sticking in F-16s was identified by witnesses (Lockheed Martin, F-16 SPO). Hardware changes have reduced but not eliminated the number of occurrences. To help identify a sticking throttle trigger, a maintenance 50-hour Forward Throttle Quadrant Inspection Technical Order (TO) 1F-16CJ-2-70FI-00-21 (-70FI) must be completed, along with a Dash 1, Flight Manual, TO 1F-16-CM-1, "STARTING ENGINE" checklist for the pilot to verify the throttle cutoff release does not remain actuated. The Pre-Flight (PR), Basic Post Flight Inspection (BPO) and 50-hour inspections on the MA were completed on the MA with zero known discrepancies. The pilot does not recall if he did or did not complete the required preflight Dash 1 throttle cutoff release check on the MA, but noted that it was in his "habit pattern." The throttle cutoff release check instructs the pilot to attempt to fully rotate the throttle outboard and pull the throttle aft to the cutoff position without actuating the trigger switch. This procedure identifies a trigger switch that is already actuated (stuck) but cannot identify future sticking/binding of the trigger switch. If during the check, the pilot is able to bring the throttle back to the cutoff position without actuating the trigger switch, the pilot is instructed to leave the throttle in the cutoff position and notify maintenance. AFRL analysis suggests that even with the pass of an on-time 50-hour Forward Throttle Quadrant Inspection and the pass of the PR/BPO Inspections, a sticking or binding throttle trigger could occur during flight.

b. Inadvertent rotation of the throttle grip

The MP does not remember if he did or did not rotate the throttle grip as he pulled the throttle from idle to cutoff position, but had selected idle position 40 times during the flight without retarding to cutoff. The F-16 SPO has no history of an F-16 throttle reaching engine cutoff position without application of full outboard rotation of the throttle grip. Under conditions of a malfunctioning throttle trigger (with a stuck/actuated throttle trigger), the MP's inadvertent rotation of the throttle grip with aft-pressure on the throttle while in idle position resulted in an unrecoverable power setting below idle thrust (throttle to cutoff position), outside the Pratt & Whitney engine restart envelope.

3. SUBSTANTIALLY CONTRIBUTING FACTORS

Substantially contributing factors include maintenance TOs that lack sufficient detail to consistently identify either a throttle trigger clevis pin misalignment or a sticking/binding throttle trigger.

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO

a. TOs lack sufficient detail to consistently identify throttle trigger clevis pin misalignment

During replacement of the throttle trigger, alignment of the throttle trigger clevis pin is critical; however, “best alignment” as described by a maintenance member is “trial and error” since the Removal and Installation of the Forward Throttle Grip Assembly highlighted in TO 1F-16CJ-2-94JG-60-2 (-94JG) refers only to allowable clearances for spacing between the throttle trigger and the throttle grip. There is no mention of a check for the alignment of the clevis pin (to include paint wear) in the PR/BPO Inspections or 50-hour Forward Throttle Quadrant Inspection. Consequently, there is no guidance in either the PR/BPO Inspections or the 50-hour Forward Throttle Quadrant Inspection to check for alignment of the clevis pin. AFRL reported that misalignment of the clevis pin in the bushing could account for the throttle trigger sticking in the retracted position.

Although not a substantially contributing factor to this mishap, consideration was given to TO inconsistencies regarding allowable number of washers and proper placement if a single washer is used. Washer placement directly affects throttle trigger clevis pin alignment. The -94JG TO, states “one or two washers may be installed with [throttle] trigger depending on allowable clearance.” Conversely, the -70FI TO states “up to three washers may be installed with [throttle] trigger, depending on allowable clearance.” Additionally, the -94JG TO states a single washer “shall be installed on the side of the [throttle] trigger that provides best alignment of the clevis pin with clevis pin slot.” However, in the aforementioned fault isolation, it reads “If only one washer is required, it shall be installed on top side of the [throttle] trigger.” Analysis concluded this incorrectly placed washer did not affect alignment of the throttle trigger clevis pin or clearances allowed in the TO.

b. TOs lack sufficient detail to consistently identify sticking throttle cutoff release

The PR/BPO Inspection TO and the 50-hour Forward Throttle Quadrant Inspection TO procedures for the throttle trigger sticking or binding are vague. Both the 1F-16CJ-6WC-1 and the -70FI TOs state “check throttle trigger for sticking or binding.” Maintenance members’ testimony reveal techniques to check for a sticking or binding throttle trigger varied in the number of actuations due to the lack of sufficient detail in the TOs.

4. CONCLUSION

I find by a preponderance of the evidence the cause of this mishap was a throttle trigger actuation and subsequent malfunction (throttle trigger stuck in retracted position) followed by the MP’s inadvertent full-rotation of the throttle grip while retarding the throttle aft to cutoff position. Substantially contributing factors include maintenance Technical Orders that lack sufficient detail to consistently identify either a throttle trigger clevis pin misalignment or a sticking/binding throttle trigger.

//Signed//

26 August 2016

BRIAN J. KAMP, Colonel, USAF
President, Accident Investigation Board

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO

INDEX OF TABS

Safety Investigator Information A

Not used B

Not used C

Maintenance Report, Records, and Data D

Not used E

Weather And Environmental Records and Data F

Personnel Records G

Egress, Aircrew Flight Equipment, and Impact Crashworthy Analysis H

Deficiency Reports I

Releasable Technical Reports and Engineering Evaluations J

Mission Records and Data K

Factual Parametric, Audio, and Video Data From On-Board Recorders L

Data From Ground Radar And Other Sources M

Transcripts Of Voice Communications N

Any Additional Substantiating Data and Reports O

Damage Summaries P

AIB Transfer Documents Q

Releasable Witness Testimony R

Releasable Photographs, Videos, Diagrams, and Animations S

Personnel Flight Records Not Included In Tab G T

Maintenance Report, Records, And Data Not Included In Tab D U

United States Air Force Accident Investigation Board Report

F-16CJ Crash, El Paso County, CO

| | |
|---|----|
| Witness Testimony And Statements..... | V |
| Weather And Environmental Records, and Data Not Included In Tab F..... | W |
| Statements of Injury or Death..... | X |
| Legal Board Appointment Documents..... | Y |
| Photographs, Videos, Diagrams, and Animations Not Included In TabS..... | Z |
| Flight Documents..... | AA |
| Applicable Regulations, Directives, and Other Government Documents..... | BB |
| Fact Sheets..... | CC |
| Search and Rescue..... | DD |
| Lockheed Martin Report..... | EE |
| Air Force Research Laboratory Report..... | FF |
| Pilot Member MFR..... | GG |