UNITED STATES AIR FORCE AIRCRAFT ACCIDENT INVESTIGATION BOARD REPORT

T-38A, T/N 68-8153

UNITED STATES AIR FORCE TEST PILOT SCHOOL
412TH TEST WING
EDWARDS AIR FORCE BASE, CALIFORNIA

LOCATION: APPROXIMATELY 12 MILES NORTH OF

EDWARDS AFB, CALIFORNIA

DATE OF ACCIDENT: 21 MAY 2009

BOARD PRESIDENT: MAJOR GENERAL CURTIS M. BEDKE

Conducted pursuant to AFI 51-503, Aerospace Accident Investigations

SUMMARY OF FACTS AND STATEMENT OF OPINION
T-38A, T/N 68-8153
21 MAY 2009

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COMMONLY USED ACRONYMS, ABBREVIATIONS, & TERMS

ABW	Air Base Wing
ADO	Assistant Director of Operations
AFB	Air Force Base
AFFTC	Air Force Flight Test Center
AFI	Air Force Instruction
AFIP	Armed Forces Institute of Pathology
AFMC	Air Force Materiel Command
AFTO	Air Force Technical Order
AIB	Accident Investigation Board
AIMWTS	Aeromedical Information Management Waiver Tracking System
AMU	Aircraft Maintenance Unit
CAMS	Core Automated Maintenance System
CERT	Certification
CG	Center of Gravity
CFETP	Career Field Education Training Program
CMTP	Civilian Master Training Plan
CSI	Critical Safety Item
DAS	Data Acquisition System
DO	Director of Operations
DoD	Department of Defense
DOD HFACS	Department of Defense Human Factors Analysis and Classification System
DT&E	Developmental Test and Evaluation
EN	Evaluator Navigator
ENJJPT	Euro-NATO Joint Jet Pilot Training
EQ	Exceptionally Qualified
FDP	Flight Duty Period
FTT	Flight Test Techniques
"g" or "G"	Gravity
GE	General Electric
HPO	High Performing Organization
IAW	In Accordance With
IMDS	Integrated Maintenance Data System
IMN	Indicated Mach Number
IP	Instructor Pilot
JSUPT	Joint Specialized Undergraduate Pilot Training
KCAS	Knots Calibrated Air Speed
KGS	Knots Ground Speed
KIAS	Knots Indicated Air Speed
KTAS	Knots True Air Speed
L	Local Time
MA	Mishap Aircraft
MAX	Maximum Power
MC	Mishap Crew
MDS	Mission Design Series
MIL	Military Power
MIL-STD	Military Standard
MIS	Maintenance Information System
MLG	Main Landing Gear
MN	Mishap Navigator
MOA	Military Operating Area
MP	Mishap Pilot
MSL	Mean Sea Level
MXS	Maintenance Squadron
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NLG	Nose Landing Gear
NOTAM	Notices to Airman
ODO	Operations Duty Officer
OEF	Operation ENDURING FREEDOM
OIF	Operation IRAQI FREEDOM
OpsSup	Operations Supervisor
ORM	Operational Risk Management
PD	Position Description
PE	Personal Evaluation
PFA	Primary Faculty Advisor
PHA	Physical Health Assessment
PIT	Pilot Instructor Training
PST	Pacific Standard Time
QA	Quality Assurance
QVI	Quality Verification Inspection
R-2508	Restricted Area 2508
R-2515	Restricted Area 2515
SEM	Scanning Electron Microscope
SI	Special Instrumentation
SLEP	Service Life Extension Program
SPORT	Space Position Optical Radar Tracking
SUPT	Specialized Undergraduate Pilot Training
TCTO	Time Compliance Technical Order
T/N	Tail Number
TO	Technical Order
TPS	Test Pilot School
TW	Test Wing
USAF	United States Air Force
USAFA	United States Air Force Academy
USAFTPS	USAF Test Pilot School
WC	Work Card
WG	Wage Grade
WS	Work Supervisor

TERMS

Attitude: The orientation of the aircraft relative to the ground. This includes pitch (nose up/down), roll (banking left/right), and yaw (nose moving left/right).

Breakout: The force required on the control stick or rudders to achieve any noticeable aircraft response.

Indicated Mach Number (IMN): The speed of the aircraft relative to the speed of sound. The speed of sound is equivalent to an Indicated Mach Number of 1.0. Also referred to simply as "Mach". For example, an aircraft flying at 0.9 Mach is flying at 90% of the speed of sound.

"g" or "G" Force: The gravitational or acceleration forces exerted on the human body during flight. As "g-forces" change, the crew member feels the experience of being "pushed" down into the seat for positive forces, and "floating" out of the seat as g-forces approach zero. May also be exerted on the crew member in both the lateral (side-to-side) and/or longitudinal (forward and back) axes.

Knots Calibrated Airspeed (KCAS): Aircraft speed as displayed to the pilot on cockpit airspeed indicators, corrected for installation errors due to airflow over the sensors. Also affected by air density changes due to altitude.

Knots Ground Speed (KGS): The speed at which the aircraft moves across the ground. Ground speed is the same as KTAS after correcting for winds. For example, if the aircraft is flying at 400 KTAS with a 50 knot headwind component, the ground speed would be 350 KGS.

Knots Indicated Airspeed (KIAS): Aircraft speed as displayed to the pilot on cockpit airspeed indicators, before any corrections are made to account for variations due to installation of components. **Note:** In the T-38, the difference between KIAS and KCAS is negligible, and therefore the two terms (KIAS and KCAS) may be used interchangeably throughout this report.

Knots True Airspeed (KTAS): The speed at which the aircraft moves relative to the airmass in which it is flying. If winds at altitude are negligible (i.e., zero knots of wind), KTAS equals speed across the ground (KGS).

Pitch: The up and down movement of the nose of the aircraft.

Roll: The change in the bank angle of the wings of the aircraft in relation to the horizon.

Yaw: The left/right movement of the nose of the aircraft in relation to aircraft's direction of travel.

SUMMARY OF FACTS

1. AUTHORITY, PURPOSE, AND CIRCUMSTANCES

a. Authority

On 28 May 2009, Lieutenant General Terry L. Gabreski, Vice Commander of Air Force Materiel Command (AFMC) appointed Major General Curtis M. Bedke to conduct an aircraft Accident Investigation Board (AIB) of the 21 May 2009 mishap involving a T-38A aircraft, tail number (T/N) 68-8153, near Edwards Air Force Base (AFB), California (CA). The investigation was conducted at Edwards AFB, CA, from 30 June 2009 through 4 August 2009. Accident Investigation Board members included: Lieutenant Colonel Stephen Geringer (legal advisor), Major Tom Ellis (pilot member), Major Scott Sullivan (flight testing advisor), Captain Ryan Davis (medical member), First Lieutenant Blythe Andrews (assistant to the board president), TSgt Sean Brown (maintenance member), TSgt Alex McCoy (maintenance advisor), TSgt Teresa Hodgson (recorder), TSgt Tara Jordan (court reporter), and Mr. William Coachman (egress systems member) (Tab Y-3 thru Y-7).

b. Purpose

This aircraft accident investigation was convened under Air Force Instruction (AFI) 51-503, *Aerospace Accident Investigation*. The purpose is to provide a publicly releasable report of the facts and circumstances surrounding the accident, to include a statement of opinion on the cause or causes of the accident; to gather and preserve evidence for claims, litigation, disciplinary and administrative actions; and for other purposes. The accident investigation is separate and apart from the safety investigation, which is conducted pursuant to AFI 91-204, *Safety Investigation and Reports*, for the purpose of mishap prevention. The accident investigation report is available for public dissemination under the Freedom of Information Act (5 United States Code (U.S.C.) §552).

c. Circumstances

The Accident Investigation Board was convened to investigate the Class A accident involving a T-38A aircraft, T/N 68-8153, assigned to the United States Air Force Test Pilot School (USAFTPS), 412th Test Wing (412 TW), Edwards AFB, CA, which crashed on 21 May 2009.

2. ACCIDENT SUMMARY

On 21 May 2009, a modified T-38A Talon equipped with the Data Acquisition System (DAS), T/N 68-8153, took off from Edwards AFB, CA at approximately 1239 local time (L) on a student Test Pilot School (TPS) training flight (Tab V-22.1). On board were two students: a student test pilot in the front seat, and a student test navigator in the rear seat (Tab K-5). The mishap crew (MC) was gathering data at an altitude of 20,000 feet Mean Sea Level (MSL) and an airspeed of 0.9 Indicated Mach Number (IMN) (Tab K-5).

Approximately 40 minutes after takeoff, the mishap aircraft (MA) experienced a failure in the rudder operating mechanism and crashed at approximately 1319L, impacting the ground approximately 12 miles north of Edwards AFB (Tabs B-3, C-3). The Mishap Pilot (MP), Major Mark Paul Graziano, was fatally injured in the impact (Tab B-3). The Mishap Navigator (MN), Major Lee Vincent Jones, was able to eject prior to impact, but sustained severe injuries in the high-speed ejection (Tabs B-3, C-3). No other military or civilian casualties occurred during this accident. The aircraft was totally destroyed upon impact, with the loss valued at $6,407,808.00 (Tab P-3). The aircraft impacted a remote area of unimproved private land with a desert landscape (Tab V-23.5).

3. BACKGROUND

The 412 TW owned the MA. The MP and MN were assigned to the USAFTPS. TPS is a unit within the 412 TW. The 412 TW, along with the 95th Air Base Wing (95 ABW), are subordinate organizations under the Air Force Flight Test Center (AFFTC). The AFFTC is a subordinate organization under Air Force Materiel Command.

a. Air Force Materiel Command (AFMC), Wright-Patterson AFB, Ohio (Tab FF-3 thru FF-5)

AFMC is an Air Force Major Command which oversees a number of major Air Force installations responsible for conducting research, development, test and evaluation, and providing acquisition management services and logistics support necessary to maintain Air Force weapons systems wartime ready.

b. Air Force Flight Test Center (AFFTC), Edwards AFB, California (Tab FF-9)

The Flight Test Center has played a critical role in the development of the country's first jet aircraft to the Air Force's newest fighter, the F-22 Raptor. The test forces at Edwards have played a role in the development of virtually every aircraft to enter the Air Force inventory since World War II. The AFFTC mission focuses on Developmental Test and Evaluation (DT&E) which is the process used to identify risks that need to be reduced or eliminated before fielding new systems. After DT&E is accomplished, aircraft systems transition to Initial Operational Test and Evaluation where the aircraft is evaluated for combat effectiveness and suitability for an intended mission. The AFFTC supports the test and evaluation programs for the Department of Defense (DoD), the Defense Advance Research Project Agency, the National Aeronautics and Space Administration, and the United States (U.S.) Air Force, Army, Navy and Marine Corps. The AFFTC is credited with providing real-time solutions during combat operations -- a direct and tangible link to the war fighter.

c. 95th Air Base Wing (95 ABW), Edwards AFB, California (Tab FF-11)

The 95 ABW is the host wing for Edwards AFB, CA, the second largest base in the Air Force, located on 301,000 acres in the middle of the Mojave Desert. The wing provides and maintains infrastructure, communication systems, security fire protection, transportation, supply, finance, contracting, legal services, manpower, housing, education and chapel services supporting over 10,000 military, federal civilian, and contract personnel assigned to the installation, as well as 25,000 dependents, veterans and retirees. Major units within the wing include: 95th Mission Support and the 95th Medical Groups, 95th Civil Engineering and Transportation Directorate, 95th Security Forces Squadron and the Services and Comptroller Divisions. Staff agencies include: chaplain services, base comptroller, inspector general, manpower and organization, equal opportunity, and public affairs. Approximately 1,500 Air Base Wing members support the AFFTC and the 412 TW mission.

d. 412th Test Wing (412 TW), Edwards AFB, California (Tab FF-13)

The 412 TW plans, conducts, analyzes and reports on all flight and ground testing of aircraft, weapons systems, software and components as well as modeling and simulation for the USAF. The 412 TW mission is comprised of flying operations, maintenance, and engineering. With a maintenance group numbering over 2,000 people and an operations group of 3,000, the 412 TW is capable of maintaining and flying 90 aircraft with upwards of 30 different aircraft designs and performing over 7,400 missions (over 1,900 test missions) on an annual basis. The Test Pilot School and Engineering/Electronic Warfare Divisions are significant entities that fall under the 412 TW. The Test Pilot School is dedicated to training the Air Force’s top pilots, navigators and engineers to conduct flight tests that generate data for aircraft design and performance analysis. The Engineering Division and the Electronic Warfare Division, also part of the 412 TW, are central components of the Test and Evaluation Mission providing tools, talent, and equipment for core disciplines of aircraft structures, propulsion, avionics/electronic warfare, and evaluation of weapon system technologies.

e. United States Air Force Test Pilot School (USAFTPS), Edwards AFB, California (Tab FF-15)

The mission of the USAFTPS is to produce highly-adaptive critical-thinking flight test professionals to lead and conduct full-spectrum test and evaluation of aerospace systems. The USAFTPS is where the Air Force's top pilots, navigators and engineers learn how to conduct flight tests and generate the data needed to carry out missions. Human lives and millions of dollars depend upon how carefully a test mission is planned and flown. The comprehensive curriculum of Test Pilot School is fundamental to the success of flight test and evaluation.

f. T-38 Talon

The T-38 Talon is a twin-engine, high-altitude, supersonic jet trainer used in a variety of roles because of its design, economy of operations, ease of maintenance and high performance. The T-38 has swept wings, a streamlined fuselage and tricycle landing gear with a steerable nose wheel. Two independent hydraulic systems power the ailerons, rudder and other flight control surfaces. The T-38 needs as little as 2,300 feet of runway to takeoff and can climb from sea level to nearly 30,000 feet in one minute. The instructor and student sit in tandem on rocket-powered ejection seats in a pressurized, air-conditioned cockpit.

The Talon first flew in 1959 and only just recently passed its 50th anniversary of flight. More than 1,100 were delivered to the Air Force between 1961 and 1972 when production ended. As the T-38 fleet has aged, specific airframe, engine and system components have been modified or replaced through a Service Life Extension Program (SLEP). Pacer Classic is the name given to SLEP that integrates essential modifications and major structural replacements into one process. These upgrades and modifications, with the Pacer Classic program, should extend the service life of the T-38 fleet to 2020.

There are several models of the T-38 in use throughout the world. The Turkish Air Force utilizes the T-38A with structural and avionics upgrades to train its student pilots. The National Aeronautics and Space Administration uses the T-38N aircraft as trainers for astronauts and as chase planes during Space Shuttle landings. The Navy uses the T-38C to train pilots at their Test Pilot School.

The Air Force uses the T-38 in several different commands for a variety of purposes. Air Education and Training Command uses the T-38C models with the avionics upgrade and propulsion modifications to train student pilots. Advanced Joint Specialized Undergraduate Pilot Training (JSUPT) students fly the T-38C in aerobatic, formation, night, instrument and cross-country navigation training. Student pilots from North Atlantic Treaty Organization (NATO) countries train in the T-38C at Sheppard AFB, Texas in the Euro-NATO Joint Jet Pilot Training (ENJJPT) Program. The T-38C prepares JSUPT and ENJJPT student pilots for front-line fighter and bomber aircraft such as the F-15E Strike Eagle, F-15C Eagle, F-16 Fighting Falcon, B-1B Lancer, B-2 Spirit, A-10 Thunderbolt II and F-22 Raptor. Air Combat Command uses the T-38A aircraft as a companion trainer aircraft for pilots assigned to aircraft such as the B-2 and U-2.

Air Force Materiel Command uses all three models of the T-38. The AT-38B is fitted with a centerline pylon and is used as a flight test aircraft at Holloman AFB, New Mexico to test experimental equipment such as electrical and weapon systems. The Air Force Test Pilot School at Edwards AFB, California uses all three models to train test pilots, test navigators, and flight test engineers. The mishap aircraft discussed in this report was a heavily modified T-38A aircraft equipped with a Data Acquisition System (DAS). The DAS includes an elongated sensor extending approximately 5 feet from the nose of the airplane that is used to capture sensitive data during flight test operations. This elongated sensor enables the aircraft to measure yaw, angle-of-attack and pitot-static inputs. Only two of these specially modified T-38 aircraft remain in existence.

g. Major Mark "Dash" P. Graziano

Major Graziano was born in New York City, New York. He graduated from high school in Wantagh, New York, and then attended the United States Air Force Academy (USAFA) in Colorado Springs, Colorado. He received his commission from the USAFA in 2000 with a degree in Aeronautical Engineering. By that time, Major Graziano had acquired a private pilot license with a glider rating and 150 hours pilot-in-command time. Major Graziano attended Specialized Undergraduate Pilot Training (SUPT) at Laughlin AFB, Texas and received his pilot wings in September 2001. While at SUPT, Major Graziano maintained better than a 98% academic average. He accomplished KC-135 copilot initial qualification at Altus AFB, Oklahoma in 2002 where he achieved a 100% academic score and an "Exceptionally Qualified" (EQ) rating on his flight evaluation. An EQ is only awarded when the aircrew member has demonstrated exceptional flying ability on an evaluation. This is typically representative of being in the top 5% of aviators in an organization. Major Graziano's first operational assignment in the KC-135 Stratotanker was at the 911th Air Refueling Squadron, Grand Forks AFB, North Dakota. There he flew missions supporting Operations ENDURING FREEDOM (OEF), IRAQI FREEDOM (OIF) and NOBLE EAGLE through 2005.

While at Grand Forks, Major Graziano earned another "Exceptionally Qualified" on his periodic flight evaluation. In 2004, while still a first lieutenant, he was a Distinguished Graduate of the aircraft commander qualification course. For this aircraft commander qualification, Major Graziano again achieved a 100% academic score and "Exceptionally Qualified" on his flight evaluation. In 2005, he upgraded to KC-135 instructor pilot earning yet again an "Exceptionally Qualified" on his flight evaluation. In 2006, Major Graziano was reassigned to the 99th Reconnaissance Squadron at Beale AFB, California to fly the U-2 Dragonlady, a sophisticated, high altitude surveillance aircraft that can provide continuous intelligence data in times of crises or war. As he had done in the KC-135, Major Graziano again flew missions in support of OEF and OIF. While at Beale AFB, Major Graziano also qualified in and flew the T-38 Talon companion trainer. It was while at Beale AFB that Major Graziano was selected for the USAFTPS at Edwards AFB, California.

Major Graziano's education included Squadron Officer School in 2006. Major Graziano's duty history includes Flight Scheduler, Flying Safety Officer, Chief of Aircrew Training, Aircraft Commander, and Instructor Pilot. While at Grand Forks AFB, Major Graziano was twice selected Pilot of the Month from among nearly 200 pilots in his operations group. He was awarded the rating of senior pilot on September 2008. Major Graziano's decorations include the Air Force Air Medal with seven oak leaf clusters for meritorious aerial achievement in both the KC-135 and U-2 aircraft. Major Graziano was the sole Distinguished Graduate from his T-38 Pilot Instructor Training (PIT) class.

Major Graziano was an extremely competent pilot with outstanding flying skills that spanned several different types of aircraft. His numerous Air Medals are evidence of Major Graziano's many aerial accomplishments, the result of discipline and passion for military aviation. His performance reports reveal someone who was willing to volunteer, take on new challenges and solve problems. Major Graziano was the consummate aviator with an impeccable record of flight evaluations. He was admired and well respected by his peers.

4. SEQUENCE OF EVENTS

a. Mission

The mishap flight was a local Edwards AFB mission executed as part of the TPS student syllabus. The syllabus designation was a Longitudinal Static Stability data flight, flown as a single ship mission within the T-38 Flying Qualities Phase, at a specific altitude and airspeed (Tab O-3 thru O-16). The students received both academic and in-flight instruction in theory and conduct of the mission (Tabs O-3 thru O-16, G-12). The curriculum was designed so that groups of students would each collect data at various combinations of airspeed and altitude as part of a larger group, in an effort to complete their assigned table of required test points (Tab DD-7). Final data analysis would be compiled in a test report written and presented by the TPS students (Tab O-3 thru O-16). The Director of Operations authorized the flight on behalf of the USAFTPS Commandant, in accordance with (IAW) AFI 11-401, AFMC Supplement 1, *Aviation Management* (Tabs BB-9, BB-45, O-18).

b. Planning

The mishap mission was thoroughly planned and briefed by the mishap crew, using the Test Pilot School's standardized "e-Brief" mission briefing guide (Tab V-2.3). A representative sample of the General Briefing Guide from the TPS e-Brief is attached (Tab DD-3 thru DD-6). According to MN testimony, the MP briefed the overall mission details and the MN briefed the specific mission objectives and test point data collection procedures (Tab V-2.3). No Test Pilot School supervisory personnel were required to attend this briefing; the MC briefed between themselves per normal ops (Tab V-2.3). The testimony of the MN confirms that the mission briefing was thorough and completely understood by both crew members (Tab V-2.4).

The mishap mission was planned to take place within the local Edwards AFB airspace. Restricted Area 2515 (R-2515) is the primary work area for most TPS curriculum flights and is a sub-section of the greater R-2508 complex. Maps depicting the R-2515 and R-2508 airspace have been provided for reference (Tab AA-3, AA-5). R-2508 is segmented into multiple Military Operating Areas (MOA) and other areas of restricted airspace. In general terms, R-2508 is bounded by the Sierra Nevada mountain range on the West, extends North to approximately the town of Bishop, California, and parallels Death Valley on the East side of the airspace before meeting the Southern border of the airspace which runs approximately East-West from Edwards AFB.

c. Preflight

The mishap crew assembled in a briefing room at the USAF Test Pilot School at approximately 1030L Pacific Standard Time (PST) to conduct the mission briefing. Notices to Airmen

(NOTAMs) applicable to the local Edwards AFB airspace were reviewed and found to contain only advisories of Unmanned Aerial System operations in the R-2515 complex but presented no restrictions relative to the time, location, or altitude of the mishap aircraft (Tab K-13). The remaining NOTAMs were comprised of ramp and taxiway closures and construction at Edwards AFB (Tab K-13). The aircraft was reported as "Crew Ready" at 1109L PST (Tab T-3). The mishap crew (MC) departed TPS to begin their mission (i.e. stepped) at 1122L, seven minutes past their planned step time of 1115L (Tab K-6).

The MC reviewed the MA maintenance forms (Tab D-9, D-15). The aircrew from the previous flight of the MA noted no discrepancies in aircraft handling (Tab D-9, D-14 thru D-15). The thru-flight inspection from the previous flight also found no flight control discrepancies (Tab D-9, D-14 thru D-15).

Initial engine start procedures were standard and allowed the mishap crew adequate time to meet their scheduled takeoff time (Tab V-1.8). However, after engine start, the MN discovered that the Personal Computer Memory Card International Association data card for the DAS on the T-38A was not recording data correctly. The mishap crew shut down the aircraft engines while waiting for the Special Instrumentation (SI) technicians to bring a different data card out to the airplane (Tab V-1.8). After installing the new data card, the mishap crew re-started the engines and continued with normal ground operations (Tab V-1.8 thru V-1.9).

The first mission event included a series of measurements that the MC conducted with engines running, while the aircraft was still in its assigned parking spot (Tabs K-5, V-2.23 thru V2.35). These measurements focused specifically on capturing the forces required to move the control stick forward and aft.

In order to measure these forces, the MP used a stick force indicator – commonly referred to as a hand-held force gage. The stick force indicator, as depicted below in Figure 1, is a mechanical device that registers the amount of force used to compress a spring between two metal plates and is operated by holding it between the operator's hand and the control stick. As the operator pushes or pulls on the control stick, the spring between the pressure plates is compressed and translated into a force measurement which the operator then reads from the gauge on top of the instrument.

Figure 1. Hand-held force gage in protective case

Per the MC's test card, the MP moved the control stick in one inch increments and read the forces required to attain each increment of displacement from the centered position of the stick (Tab V-2.25).

The mishap crew departed Edwards AFB via a locally assigned "PANCHO 2" clearance issued for operations in the R-2508 complex (Tab K-3 thru K-4). The PANCHO 2 clearance authorizes aircrews to operate within R-2515 from the surface up to 60,000 feet MSL, and also includes operations in other work areas within the greater R-2508 MOA with additional altitude restrictions (Tab K-3 thru K-4).

d. Summary of Accident

The mishap mission was a Longitudinal Static Stability data acquisition flight, focused primarily on capturing data points at 20,000 feet MSL and at 0.9 Mach. Additional points in the Powered Approach configuration were also planned at 10,000 feet MSL and were to be flown at approach airspeeds with the aircraft configured for landing, with the landing gear extended and flaps set to 60% (Tab K-5). Scheduled mission times were as follows (Tab K-5, K-9):

Crew Step: 1115L (Actual Step: 1122L (Tab K-6))
Engine Start: 1140L
Taxi: As required to meet takeoff time
Estimated Time of Departure: 1200L
Actual Time of Departure: 1239L (Tab V-22.1)
Estimated Time of Arrival: 1305L

Mishap mission ground and flight maneuvers included an evaluation of aircraft handling qualities during taxi followed by a full afterburner or Maximum power (MAX) takeoff. The climb to 20,000 feet MSL was conducted with Military power (MIL), which is the highest thrust setting available without the use of afterburner. Mission events included the performance of various Flight Test Techniques (FTTs) within R-2515 to capture flight test data, with specific focus on the pitch stability of the T-38 aircraft while configured with a forward Center of Gravity (CG) (Tab O-3 thru O-16). Pitch stability, in general terms, is used to characterize how sensitive the aircraft's nose up or down response is to pilot inputs or small changes in airspeed. Test points at 10,000 feet MSL with the aircraft configured for landing and flown at approach airspeeds were planned to be completed towards the end of the mission profile but were not executed. Specific planned mission events can be referenced on the crew mission line-up card (Tab K-5).

The takeoff and mission were uneventful until the planned zero-gravity (zero-g) pushover maneuver, as executed in test card #10 (Tabs V-1.2, V-2.29, K-5). During that zero-g pushover maneuver, the stick force indicator floated up in the front cockpit, landing on the ledge which is located above and behind the MP's ejection seat (Tab V-1.2, V-1.15, V-2.11). After completing the test point, the MP conveyed what had happened, and the MN responded with an acknowledgement, and a comment that the stick force indicator was visible from the back seat and was not in a position to threaten flight safety (Tab V-1.2). After discussing the results of the zero-g pushover, including qualitative comments about the data gathered, the MP made a comment that he was going to attempt to retrieve the stick force indicator (Tab V-1.2). The MN testified that immediately after he acknowledged the MP's comment with an "Okay…" the aircraft experienced a sudden sharp and unexpected negative-g onset (Tab V-1.2). The MN testified that this pushover was much more abrupt than expected and not consistent with the previous pushovers performed as part of the planned mission profile (Tab V-1.2, V-1.19).

Following the abrupt negative-g onset, the MN testimony indicates that he witnessed the MP rise up out of his seat and hit his helmet on the canopy after which the MN experienced a possible momentary loss of consciousness (Tab V-1.2). When the MN regained consciousness, he was only able to see "white", possibly due to compounding physiological effects of high "g" forces in multiple axes, and was therefore unable to discern aircraft attitude (Tab V-1.2 thru 1.3, V-21.1). The MN cognitively concluded that due to the negative-g event, the aircraft was in a rapid descent at a high rate of speed (Tab V-1.7). The MN's testimony highlighted many gaps in his memory of the event and the order in which specific events took place (Tab V-2.7). Although the MN's recollection of the order of events is uncertain, he did remember retarding the throttles towards idle and making control inputs to which he felt no discernable aircraft response (Tab V-2.7). He did not feel any control inputs from the MP. The MN made multiple unsuccessful attempts to communicate with the MP, and after getting no response from the MP, the MN made the determination that the MA was out of control and called for the MP to bail out of the aircraft (Tab V-2.7). Although the MN does not recall having any difficulty reaching the ejection handle, he believes that he only used his right hand to initiate ejection (Tab V-1.3). The MN sustained serious injuries during the ejection (Tab C-3).

This T-38A was equipped with a DAS system capable of recording flight test parameters. However, the DAS recording unit was not designed to be "crash survivable" like Crash Flight Data Recorder units installed on commercial passenger airplanes. As such, specific ejection parameters for the MN's ejection (i.e. altitude, attitude, airspeed) are undetermined, although analysis by egress system experts estimate that the MN initiated ejection above 10,000 feet MSL and between 580-600 KTAS (Tab H-16). Inspection of ejection seat components recovered from the impact site confirmed that the MP did not initiate ejection and was fatally injured upon impact (Tabs B-3, H-16).

Through analysis of flight control actuators recovered from the impact site, it has been determined that the rudder was positioned at a full deflection of 30 degrees to the left prior to impact (Tab V-19.2). Due to the design of the rudder operating mechanism, the normal in-flight limit is 6 degrees; T-38 mechanical engineering systems experts have confirmed that this malfunction is only possible when the rudder flight control system becomes disconnected between the rudder force producer spring and the rudder operating crank, either through materiel failure or improper installation of components (Tab V-19.4). While specific details of this malfunction can be found in the subsequent Maintenance section of this report, it is worthwhile to note that this condition causes the aircraft to depart controlled flight and is unrecoverable in the T-38 (Tab II-35 thru II-36).

The AIB noted that the mishap sequence appeared (according to MN testimony) to have begun at the moment the MP applied a pushover (nose down) stick force to the aircraft, and that a sudden sharp and unexpected negative-g onset occurred (Tab V-1.2). (Note that a common technique for retrieving items that float up and to the rear of the cockpit is to push the nose over to a slight negative-g condition—thus floating the item upwards—and reduce power slightly to slow the aircraft and allow the item to float forward, where it can then be retrieved.) Thus, the AIB had to consider the possibility that the MP applied an excessive nose down force to the stick, either intentionally or by accidentally bumping the stick, thus causing the two aircrew to hit their helmets and become incapacitated.

On the other hand, this did not appear to explain the 30-degree hardover rudder, which clearly occurred while the aircraft was in flight ('witness' marks on both rudder actuators caused at the initial impact proved the rudder was already in this position at the moment of impact.) (Tab J-14).

The AIB considered, but dismissed, the possibility that the MP applied too much force. The MP had just completed a series of build-up points, pushing the aircraft gently nose down from the normal 1.0g condition to 0.7g, holding it, recovering, then pushing it to 0.5g, holding it, recovering, then pushing it to 0.0g, holding it, and recovering (Tabs V-2.29, V1.2). This build-up approach, especially for a pilot who was specifically testing the forces required to perform this task, gives strong evidence that the MP did not misapply the stick forces required.

The AIB found no evidence to believe the MP accidentally bumped the stick. The MN did not witness any twisting, turning or bending in the seat by the MP prior to the onset of negative-g, and specifically did not see the MP turning to position himself to see the force gage (Tab V-2.8).

The AIB then considered the possibility that the slight negative-g pushover may have caused the 30-degree hardover rudder. As the primary T-38 flight controls engineer considers it highly likely that a maintenance error allowed an improperly secured nut to become unseated (Tab V-19.4), the AIB examined and found highly likely the scenario that one of the seven bolts securing two of the rudder operating mechanism "Critical Safety Items" had worked its way almost free over time, and the zero-to-negative g condition gave the bolt enough free play to allow it to finally work all the way free.

Post-mishap aerodynamic engineering analyses performed by a technical expert at Hill AFB, Utah, were used to characterize the motion of the aircraft after the rudder flight controls were disconnected from the rudder actuators (Tab V-20.1). Four representative scenarios were developed for analysis with varying initial conditions for aircraft "g" loading. All four cases resulted in abrupt and simultaneous oscillating aircraft motions in the pitch, roll, and yaw axes (Tab V-20.7). The most likely case of the four scenarios was determined by the engineering expert's analysis of radar data, aircraft trajectory, and witness testimony. This most likely case was initiated with the rudder components becoming disconnected when the aircraft was at a zero to slightly negative "g" condition (Tab V-20.7, V-20.14 thru V-20.15).

Computer simulations of this case resulted in aircraft roll rates as high as 160 degrees per second, coupled with high lateral (side-to-side) and vertical g-forces as experienced by the aircrew (Tab V-20.7, V-20.14). These aircraft motions initially induced extreme forces on the aircrew and dampened out over time (Tab V-20.7). Although high lateral g-forces are well tolerated physiologically, the correlation of factors (i.e. lack of communication with the MP, lack of control inputs at impact, failure to initiate ejection) raise the possibility that these forces resulted in an overwhelming and incapacitating spatial disorientation or unconsciousness, especially when coupled with simultaneous high accelerations in other axes (Tab V-21.1).

The motions of the aircraft, as demonstrated by the engineering analysis, are supported by the MN's description of the aircraft motions. The MN reported an extreme negative "g" onset, followed by a period where he was unable to describe the motions of the aircraft (Tab V-1.2). After regaining awareness, the MN was unable to recall feeling any extreme aircraft accelerations (Tab V-2.16), which is supported by the engineering analysis that shows the forces dampening out over time. While it is impossible to say for certain whether the MP was unconscious from the time of the negative-g event to impact, the lack of flight control inputs at impact, the lack of response to the MN's repeated attempts to communicate with the MP, and the failure to initiate ejection support the assumption that he was incapacitated by the initial aircraft upset and never regained awareness.

Several factors were considered and determined not to have contributed to the mishap. Testimony from the MN indicated that weather had no adverse effect on mission execution (Tab V-1.12). All mishap mission events took place within the R-2515 complex and the southern portion of the Isabella MOA (Tab V-22.1). Air Traffic Control services were provided initially by the Edwards AFB control tower followed by the Space Position Optical Radar Tracking (SPORT) radar controller after the mishap aircraft had departed the control tower's airspace (Tab V-22.1). MN testimony and audio recordings provided by both the Edwards AFB control tower and SPORT control were not indicative of any communication problems experienced between the mishap crew and air traffic control agencies (Tab V-2.5, V-22.2). Radar data provided by SPORT also indicated that there were no traffic conflicts with the mishap aircraft that could be attributed to complicating the mishap crew's mission in the moments preceding the mishap event (Tab V-22.2).

Terrain was not found to be a contributing factor to this mishap. Following the initial takeoff from Edwards AFB, the MC climbed to and remained at approximately 20,000 feet MSL until the mishap event that led to the MA rapid descent in a northwest direction and impact with the ground. Navigation within the R-2515 complex was conducted by visual identification of ground references. This fact eliminates a navigational system malfunction as a contributing factor to this mishap.

e. Impact

The MA impacted the ground at approximately 1319L (Tab B-3). Descriptions of the impact site show the aircraft impacting the ground in a south sloping desert area traveling in a northwest direction (Tab J-3). The ground scar was approximately 16 feet wide and 33 feet long and approximately 2.5 feet deep (Tab J-3). Site recovery operations indicated, at impact, the engines were at idle (Tab J-16) with the landing gear and flaps up (Tab J-15, J-16). Actuator positions confirmed that the ailerons and horizontal stabilizer were neutral (Tab J-15), speed brakes were retracted (Tab J-15), and the rudder was fully displaced to 30 degrees left (Tab J-15).

Due to the damage sustained during impact, aircraft pitch, roll, and yaw angles at the time of impact could not be determined (Tab J-3). The debris field extended to an area approximately 0.75 x 0.25 miles (Tab J-3).

f. Life Support Equipment, Egress and Survival

Egress, survival, and life support equipment items were identified and submitted for analysis. This equipment included the MP and MN ejection seats, drogue chutes, explosive components, canopy glass pieces and components life support, survival equipment components and personnel parachutes (Tabs H-6 thru H-16, J-25 thru J-91).

The MP did not initiate ejection from the MA and was secured in his seat at the time of the MA impacting the ground (Tab H-16).

The MN initiated ejection from the MA at approximately 1318L. The estimated parameters at the time the MN initiated ejection place the MA between approximately 480-530 KCAS (580-600 KTAS) and above 10,000 feet MSL (Tab H-16). Due to uncertainties with the exact altitude at the time of ejection, the speed range of 480-530 KCAS resulted in an ejection that may have exceeded the maximum recommended airspeed of the Northrop Improved Ejection Seat of 500 KIAS (Tab H-16).

Post-mishap aerodynamic engineering analyses of the mishap flight profile indicate that the aircraft was both rolling and yawing at the time the MN initiated ejection (Tab V-20.14 thru V-20.15). As configured, the ejection envelope is zero (0) feet altitude and fifty (50) knots forward velocity with wings and pitch attitude approximately level (Tab H-5). Any increase in aircraft pitch, roll or sink rate will reduce the safe escape envelope (Tab H-5). The estimated descent angle of 39 degrees, coupled with the calculated rolling and yawing motions of the MA, make it highly likely that the MN initiated ejection outside of safe escape envelope (Tab V-20.15).

The MN canopy jettison sequence and ejection of the seat performed properly, despite the probability of exceeding the safe ejection envelope parameters (Tab H-16).

(1) System Deficiencies or Maintenance

Immediately following ejection, the MN drogue chute deployed, with the drogue chute riser and suspension lines entangling with the drogue chute sleeve, drogue gun bridle with slug, oxygen mask communication cord, the drogue chute restrictor release lanyard and a Test Pilot School issued electronic stopwatch. This entanglement prevented full deployment of the MN ejection seat drogue chute (Tabs H-16, J-33).

(2) Inspection Currency

No deficiencies with the life support equipment were noted. All life support and survival equipment inspections for both the MP and MN were current (Tab U-3 thru U-5, U-93 thru U-95, U-113 thru U-115, U-121 thru U-123). Both the MP and MN were wearing the required equipment for a local training sortie (Tab U-121 thru U-123).

The escape system inspections were accurate and current and the equipment operational at the time of mishap (Tab U-7, U-117 thru U-119). Egress Final inspections on the MP and MN ejection seats and canopies were accomplished on 09 April 2009 and 15 April 2009 (Tab U-71 thru U-72).

g. Search and Rescue

The MA impacted the ground approximately 12 miles North of Edwards AFB at approximately 1319L on 21 May 2009. Initial notification of the mishap was relayed from an eyewitness to the NASA Dryden Safety Office at approximately 1324L (Tab R-6). Edwards AFB Command Post received an initial report of a possible airplane crash at 1326L (Tab EE-11). At 1330L the same eyewitness called the NASA Flight Operations office after making contact with the MN (Tab R-6). Quick Reaction Checklist #11 (Major Accident Response – Actual or Exercise) was initiated at 1347L (Tab EE-3, EE-7 thru EE-9). Edwards AFB firefighters (Callsign: “CRASH”) and fire chiefs (Callsign: “CHIEF”) arrived on scene and made contact with the MN at approximately 1412L (Tab EE-23). Crash/Rescue assets sent to the scene included three P-19 Airport Rescue Fire Fighting trucks, one P-26 Water Tanker truck, one P-30 Fire vehicle, and three Command and Control vehicles (Tab EE-25).

A medical evacuation helicopter, operated by Mercy Air, arrived on-scene at approximately 1427L and departed with the MN at approximately 1444L, en-route to the Kern Medical Center located in Bakersfield, CA (Tab EE-23). At 1552L, CRASH32 notified CHIEF2 that the impact site of the mishap aircraft had been located (Tab EE-24). At approximately 1644L, CHIEF1 was notified that the on-scene flight surgeon had confirmed that the MP was fatally injured in the crash of the aircraft (Tab EE-24).

Weather does not appear to have hindered the rescue effort, nor did the time of day at which the mishap occurred adversely affect search and recovery operations. The MN landed approximately 30 feet from a dirt road, approximately 1 mile from the end of the connecting paved road. The impact site of the MA was located several miles northwest of where the MN was found. Both the location of the MN and the MA impact site had adequate access via dirt roads approaching from multiple directions. Due to the remote location of the impact site, no civilians were on-scene at the time of the mishap. The only civilians on-scene at the location of the MN were the eyewitnesses who made the initial notification of the mishap.

h. Recovery of Remains

The first responders to the MN landing site were NASA employees. At 1444L on 21 May 2009 the MN was transported via Mercy Air (civilian air evacuation helicopter) to a local hospital (Tab EE-23). At 1644L the MP remains were found and he was declared deceased by the on-site flight doctor (Tab EE-24). Remains of the MP were collected during recovery operations and sent to the Kern County Coroner's office for autopsy (Tab X-3). The MP was interred at Arlington National Cemetery.

5. MAINTENANCE

Discovery of the 30 degree hardover rudder led the AIB to a full review of maintenance procedures, documentation, and training.

a. Maintenance Procedures

According to the Accident Investigation Board's technical advisor, the Air Force T-38 System Program Office's primary T-38 flight controls engineer, there are two possible causes of the rudder failure: 1) a structural break in a critical component or bolt, or 2) a maintenance error in which hardware such as a nut or cotter pin was not properly installed. In his opinion, it is highly likely that an improperly secured nut became unseated, disconnecting the flight controls from the rudder actuators. As evidenced by two other T-38 mishaps with 30 degree hardover rudder failures, both cases were absolutely proven to be the result of improperly secured fasteners on connecting rod "A" (Tab V-19.4). It is highly unlikely that mechanical fatigue, such as a bolt breaking, could have caused this failure (Tab V-19.4). The rudder is normally limited to six (6) degrees of deflection with the landing gear in the retracted position. In order for the rudder to be able to obtain 30 degrees deflection with the landing gear retracted, a component failure of a Critical Safety Item (Figure 2) must occur (Tab V-19.3).

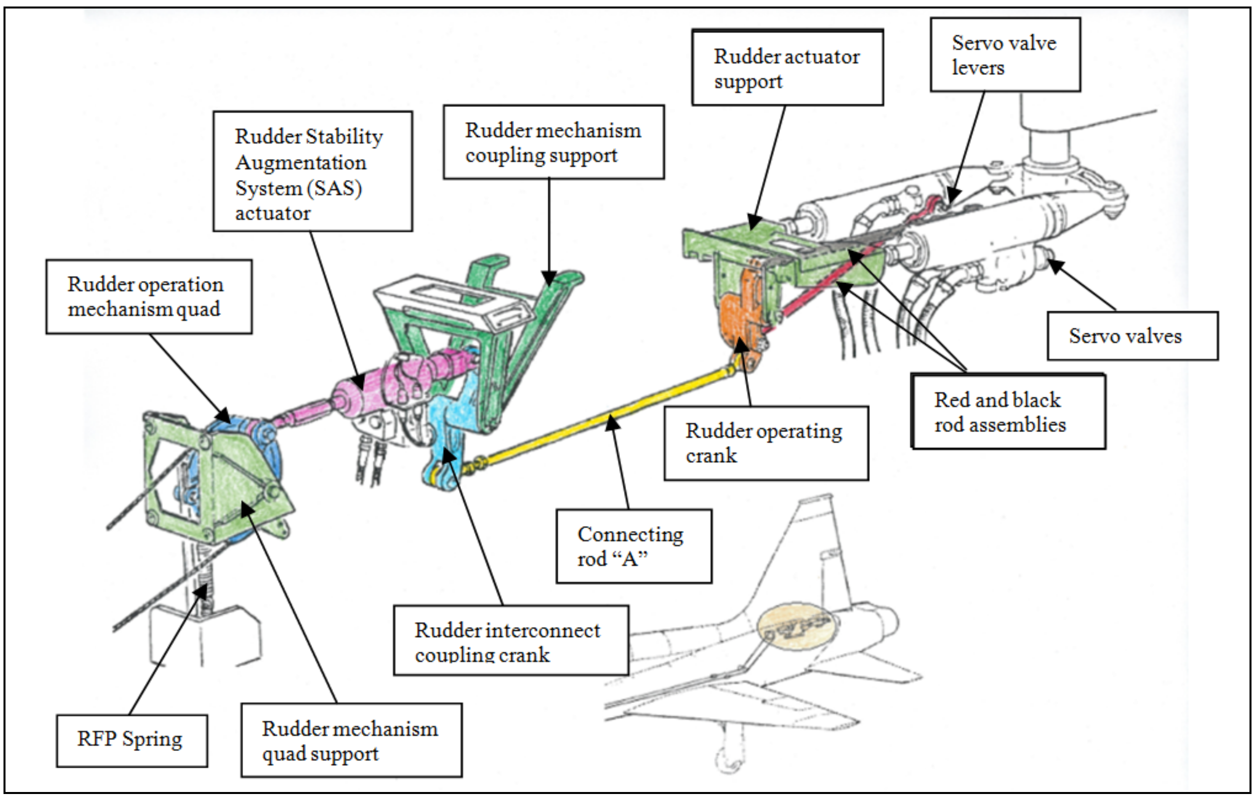


Figure 2. Rudder Operating Mechanism Critical Safety Items (CSI)

The last documented maintenance actions on the rudder operating mechanism were during the last 900 hour major phase inspection from 20 October 2008 to 2 January 2009. It was also the last documented opportunity to discover and correct any maintenance deficiency within the rudder operating mechanism, either by the phase maintenance personnel (Tabs U-43 thru U-69, V-17.3, V-17.4) or Quality Assurance personnel (Tabs U-103 thru U-105, V-18.2). Anomalies with the Quality Verification Inspection (QVI) are discussed below under "Inspections."

b. Maintenance Documentation

A detailed review of the active and historical Air Force Technical Order (AFTO) Form 781 series (aircraft maintenance forms) for the three months preceding the mishap revealed no MA discrepancies with documentation (Tab D-11 thru D-15). The Integrated Maintenance Data System (IMDS) historical records for 90 days prior to the mishap were used to validate and confirm all form entries (Tab U-9 thru U-41). Jet Engine Intermediate Maintenance records reviewed showed all time changes and Time Compliance Technical Order (TCTOs) were completed (Tab U-97 thru U-99). Review of all servicing AFTO Forms 134 and AFTO Forms 244 revealed no discrepancies (Tab D-30, U-81 thru U-85). According to Air Force Instruction (AFI) 21-101, *Aircraft and Equipment Maintenance Management*, handwritten 781As must be stored for a minimum of three months after which they may be destroyed. In accordance with that instruction, it is 412 MXG policy to destroy 781As after three months. Thus, the AFTO 781s preceding the three months prior to the mishap (including the ones from phase) were not available for review (Tab BB-55).

The maintenance unit divides maintenance assignments into aircraft maintenance units (AMUs), or "flight line" maintenance, and Aircraft Inspection Sections, or "phase" maintenance units (Tab BB-52, BB-54). "Phase" is a common term used to describe a major inspection, overhaul, and maintenance performed on an aircraft at a specific point in its lifetime based on hours flown (i.e. 900-hour Major Phase Inspection). A phase Work Lead testified that a crew chief from the aircraft's owning AMU would accompany the aircraft to augment the phase maintenance unit (Tab V-16.7). Work performed on the aircraft in phase was documented in two places: on the Air Force Technical Order (AFTO) Forms 781 (handwritten forms) and in the IMDS (a computerized records database) (Tab BB-51). A Work Lead testified that IMDS would only allow him to sign off work if all people listed as performing that task were from the same maintenance unit. For example, he could not sign off a phase maintainer as completing work with an AMU crew chief (Tab V-16.2). He stated that he substituted his name in IMDS for the actual AMU crew chief that performed the work during phase. In addition, he stated that this was common practice and could not be avoided (Tab V-16.3). Due to this practice, the Accident Investigation Board was never able to determine the identity of the aircraft maintenance mechanics and inspectors who last worked on and examined the aircraft in phase (including those that worked on the rudder system).

c. Inspections

A review by the Accident Investigation Board of the AFTO Form 781K revealed that one TCTO, 1T-38-816 (MOD T-38 weapons system support POD central) a DEPOT level TCTO, remained open but did not have a ground date until 15 February 2010 (the ground date is the date it must be complied with, or the aircraft is not allowed to fly). All TCTOs had been accomplished in accordance with applicable guidance (Tab U-79 thru U-80). TCTO compliance did not contribute to the accident.

Both MA engines were GE J-85 engines. The #1 engine (left engine), serial number GE00232256, had 8,226.0 hours total engine operating time. The #2 engine (right engine), serial number GE00231035, had 6,148.4 hours total engine operating time (Tab D-17). An engine phase inspection was accomplished on engine #2 on 13 November 2008 (Tab U-97) and on engine #1 on 8 May 2007 (Tab U-99). The last engine trim for engine #2 was performed on 12 March 2009 and for engine #1 on 10 March 2009 (Tab U-87). The investigation revealed no overdue inspections (Tab U-89 thru U-92).

The 900 hour major phase inspection was completed on 2 January 2009 with approximately 10,060.1 hours on the airframe. The MA accrued 75.3 hours between the last inspection and the mishap (Tab D-3). At the time of the mishap, the MA total aircraft time was 10,135.4 hours. One possible problem identified by the Accident Investigation Board was the 412 MXG method of performing the T-38 Quality Verification Inspection (QVI). This inspection was performed differently on the T-38 than on other airframes in the 412 MXG. Normally, the entire phase maintenance work would be completed prior to the QVI. Once all the phase maintenance was completed, quality assurance (QA) would perform their inspections. Because of the T-38 Phase Flow Improvement process, however, the T-38 phase QVI was broken up into sections (e.g. fuselage, wings, cockpit, etc.) (Tabs V-18.4, II-9 thru II-30). Once the maintenance of a section was completed, QA would come out to inspect it. If no discrepancies were discovered, QA would sign off the section and wait for the next section to be completed. Under this practice, panels of the aircraft would remain off while maintenance was still being performed in the general area. The Work Lead testified that phase maintenance would occasionally be extended if Plans and Scheduling added something new to the phase package (Tab V-16.10). There was no requirement for QA to do a follow up inspection once the section was signed off. This presented an opportunity for an item to be improperly installed, or a foreign object to be left behind, after the partial QVI had been accomplished.

d. Maintenance Training Policy

In 2004 the 412 MXG enacted a High Performing Organization (HPO) pilot program designed to replace active duty maintenance crews with civilian counterparts (Tab BB-79 thru BB-83). AFI 21-101 directs maintenance training requirements (Tab BB-47). Due to the unique structure of the HPO, the 412 MXG was given a waiver from HQ USAF/A4L that cited which parts of AFI 21-101 were not applicable or where alternate methods of performance were authorized (Tab V-13.17 thru V-13.46). In order to comply with that waiver, the 412 MXG Commander had written a Civilian Master Training Plan (CMTP), published 2 August 2006 (Tab BB-73 thru BB-78). The CMTP directed specific 412 MXG HPO civilian training (Tab BB-73 thru BB-78).

Official maintenance policy, as could be determined through a review of the HPO program, pertinent AFIs, the CMTP, and the 412 MXG Chief of Maintenance Training Division's testimony is described below. Each aircraft mechanic is required to have an individual training record. This training record tracks and records authorized maintenance actions for each aircraft mechanic (Tabs V-14.4, BB-73 thru BB-78). Specifically, if the aircraft maintenance mechanic was not signed off on a task in their training record, they were not to perform it without qualified supervision (Tab V-14.12). Training records are composed of Job Qualification Standards. Job Qualification Standards are lists of mission design series (MDS) specific tasks. Each MDS an individual is authorized to work should be documented on a separate Job Qualification Standards list. For example, a maintenance mechanic authorized to work on F-16's and T-38's would have two Job Qualification Standards lists in their training record (Tab V-14.5).

The Job Qualification Standards list divided tasks into three categories – core tasks, regular maintenance items, and special certification items. Core tasks were the central actions and inspections most aircraft mechanics should know, and were typically the first ones learned by an individual. Special certification items were procedures that required special training (including the attendance of specific, specialized classes) and proficiency demonstration (Tab BB-77). The 412 MXG Special Certification Roster documented individuals trained and certified to perform Special Certification items (Tab V-25.1).

e. Maintenance Training Execution

Interviews of six aircraft maintenance mechanics, a 412 MXS Work Lead, a 912 AMXS AMU Chief, a Quality Assurance Inspector, and the 412 MXG Chief of Maintenance Training Division, indicated a difference in the understanding of training policies between supervision and aircraft maintenance mechanics. The 412 MXG Chief of Maintenance Training Division testified that the training plan set forth in the CMTP was the official training plan. If a mechanic was not signed off on a task in their individual training plan, that mechanic should not be doing that task unsupervised (Tab V-14.12). However, testimony by the Work Lead, and the majority of aircraft mechanics interviewed, was that they were considered fully qualified and trained to accomplish any maintenance task. This included assigned tasks, or those that were listed under their position description, following an evaluation of their work history at the time they were hired (Tab V-10.5, V-11.5, V-16.8).

Aircraft mechanics interviewed were under the assumption they were hired as an Aircraft Mechanic, either with an Airframe and Power Plant (A and P) license or military background, which made them qualified to work any Mission Design Series (MDS) (Tab V-9.5 thru V-9.6, V-10.6, V-11.5). One stated he was qualified to perform all maintenance work listed in the position description he was hired under (Tab V-11.5). Another mechanic was asked about training requirements, and he replied that by signing his position description he was saying he should be able to change out actuators on any aircraft (he was specifically asked about T-38, F-16, and B-52). He went on to say that he did not have to be signed off on actuators prior to working on them, did not have to demonstrate proficiency, and that his ability to work on actuators was understood "as part of getting hired on" (Tab V-10.6).

The training records for the interviewed aircraft maintenance mechanics revealed multiple deficiencies (Tab HH-1 thru HH-169). One aircraft mechanic testified that he had performed an authorized unsupervised inspection of the MA, but a review of his T-38 training record revealed he had not received the training for, nor was he qualified to accomplish, the inspections that he subsequently signed off (Tabs V-9.3, HH-77 thru HH-97). The testimony and training records of the aircraft mechanics interviewed revealed some training requirements had not been met or not been documented. In the vast majority of cases, the aircraft maintenance mechanic had likely received appropriate training in the past (almost all civilian employees interviewed testified to having prior military service, most in the Air Force as upper level maintenance mechanics.) However, lack of documentation in the training records made verification impossible (Tab V-9.7, V-10.6, V-16.8). The 412 MXG was not following the HPO waiver from AFI 21-101 requirements or the training policies in place, and this led to aircraft mechanics performing work without the proper training documentation.

The AIB also found discrepancies with the Special Certification documentation. According to the 412 MXG Civilian Master Training Plan, Appendix C, T-38 Flight Control Rig is a Special Certification Roster item. In order to accomplish that task, the aircraft mechanic must have been formally trained and listed on the Special Certification Roster in IMDS (Tab V-24.1, V-24.3). However, the 412 MXG Special Certification Roster did not list T-38 Flight Control Rig as a Special Certification item, and no other documentation existed that would allow anyone in the maintenance group to perform that work (Tab V-25.1). Thus, no maintenance member in the 412 MXG was documented as being authorized to rig a T-38 rudder system IAW the CMTP.

When interviewed about T-38 flight control rigging, the work lead stated that an instructor had been flown in from Texas to teach a rigging class. After attending the class for three weeks, he was not provided a certificate of training because the instructor had not been through the "Train the Trainer" course and therefore was unable to certify the students. He went on to say that the class was a "nice to have" as opposed to a mandatory requirement (Tab V-16.9).

An Aircraft Maintenance Unit Chief was unaware that T-38 Flight Control Rig was a Special Certification item (Tab V-13.5 thru V-13.6) in accordance with 412 MXG High Performing Exceptions Document and the Civilian Master Training Plan (Tab V-13.19, V-24.1, V-24.3). He also doubted the veracity of the CMTP itself by asking if it was valid and signed by the Maintenance Group Commander (Tab V-13.5).

The AIB found that monthly reviews of employee training records were not being documented within the guidelines set forth in 412 MXG Civilian Master Training Plan (Tab V-13.7, V-14.9). Some individuals' training records lacked documentation of review on the Job Qualification Standard Review Sheet in each Individual Training Plan dating back to November 2008 (Tab HH-123).

The AMU Chief testified that all training records are reviewed "once a month. The Work Leads are responsible to go back through their folders" while the Work Lead testified "The way that I understand it is, we were all hired as aircraft mechanics and we do not work off of the training records." The Work Lead continued to state, "To be honest, I'm under the impression that we don't need training records signed to do maintenance" (Tab V-13.7, V-16.8).

These examples clearly illustrated the difference in the perception of training policy among supervisory levels. Interviews of 412 MXG mid-level supervision indicated a lack of communication, a lack of discipline, and noncompliance with applicable instructions regarding maintenance training and training documentation.

f. Fuel, Liquid Oxygen, and Oil Inspection Analysis

Fuel, Oil and Liquid Oxygen were determined not to be factors in the mishap.

Oil samples were examined for contamination by Edwards AFB Non-Destructive Inspection and no discrepancies were noted (Tab U83 thru U-85). Fuel samples from the fuel truck that refueled the MA were analyzed by Aerospace Fuels Laboratory at Wright-Patterson AFB and no discrepancies were noted (Tab U-107, U-110). Liquid Oxygen samples were taken from the Liquid Oxygen servicing cart that serviced the MA and were analyzed by Aerospace Fuels Laboratory at Vandenberg AFB with no discrepancies noted (Tab U-111 thru U-112). All inspections were current at the time of the mishap.

g. Unscheduled Maintenance

Unscheduled maintenance was not a factor in the mishap.

On 19 February 2009, the MA number one engine did not start. An aircraft maintenance mechanic replaced the Main Ignitor plug, Lead, and Exciter, and tested the engine in the test facility. The engine tested normal, was reinstalled, and the aircraft was returned to service (Tab U-77).

On 11 March 2009, the MA number two engine stalled in-flight. Aircraft maintenance mechanics ran the engine stall checklist and discovered the overspeed generator lever was not secure and was found in the low speed position. The lever was repositioned to normal and the aircraft was returned to service (Tab U-76).

On 17 March 2009, the MA number one engine did not start. The engine was removed and the Exciter was replaced. The engine was reinstalled, operational checks were complied with, and the aircraft was returned to service (Tab U-75).

On 30 March 2009, the MA number two engine instruments were inoperative. During examination, a connector was discovered loose, then reconnected before the MA was returned to service (Tab U-74).

On 19 May 2009, both MA engines were examined for high Exhaust Gas Temperature reading at idle. Operational checks were performed and both were within operational limits (Tabs U-73).

The 912 Aircraft Maintenance Squadron completed all corrective actions in accordance with applicable technical data.

6. AIRCRAFT AND AIRFRAME SYSTEMS

a. Conditions of Systems

Due to catastrophic damage to the aircraft on impact, few discernable parts of the various structures and systems were found.

The following items that were recovered (with the exception of the engines and landing gear) were sent for teardown and analysis by the laboratory of 558 ACSG/ENB, Ogden Air Logistics Center (AFMC) Hill Air Force Base, Utah, with results as follows:

(1) All of the following component damage was determined to be due to overstress consistent with damage from crash impact. None of these components were a contributing factor in this mishap.

a. Aileron Actuators Based on teardown analysis, witness marks inside the actuators from impact indicated that the ailerons were neutral (Tab J-15).

b. Horizontal Stabilator Actuators Based on witness marks inside the actuators from impact, horizontal stabilators were neutral at the time of impact (Tab J-15).

c. Flap Actuators Based on the position of the flap motor actuator arm, flaps were in the up position (Tab J-15).

d. Speed Brakes Actuators The speed brake actuators were in the retracted position at the time of impact, indicating that the speed brakes were retracted (Tab J-14).

e. Rudder Travel Limiter Microscopic investigation of the component showed chevrons caused by overstress factors consistent with crash impact (Tab GG-18).

(2) Items listed below are Critical Safety Items (CSI) components of the Rudder Operating Mechanism recovered from the crash site. As stated above in Section 5, paragraph C., incorrectly installed hardware in the area between the Rudder Force Producer Spring and the Rudder Actuators is the most likely cause of the 30 degree hardover rudder. Due to the extensive damage to the MA, not all components of the Rudder Operating Mechanism were recovered.

a. Rudder Actuators The left rudder actuator teardown and analysis reveal impact marks at the 0.05 inches, which equates to 30° left rudder deflection. The right rudder actuator showed impact marks measured at 3.4 inches, which equates to a 30 degree left rudder deflection. Because of the rudder travel limiter mechanism, a 30 degree rudder deflection is normally not possible with the landing gear retracted (Tab J-14).

b. Rudder Interconnect Coupling Crank Analysis of the crank under a scanning electron microscope (SEM) revealed that the part was broken due to ductile overstress (crash impact) and not due to fatigue (cracks) (Tab GG-14 thru GG-15).

c. Rudder Stability Augmentation System (SAS) Actuator The actuator was found in the neutral position. All components were broken free during impact due to ductile overstress, and the only component recovered was the hex rod (Tab J-9).

d. Rod "E" or Red Rod Both ends of the red rod were recovered, as well as a section of the adjustment portion of the rod itself. Analysis under the SEM revealed that the red rod was broken due to ductile overstress. On the end of the rod that was connected to the rudder operating crank, the bearing was completely torn out. On the rod end that was connected to the control arm of the right rudder actuator, the bearing was intact with minimal damage (Tab GG-4 thru GG-9).

e. Rod "F" or Black Rod Only the end of the black rod that was still connected to the control arm of the left rudder actuator was recovered. The bolt was still intact through the control arm and the rod end, and the bearing in the rod end was severely damaged. Analysis revealed damage due to ductile overstress (Tab GG-10).

f. Rudder Force Producer Spring The spring was found to have 7 coils broken off on one end. Analysis revealed that damage was due to ductile overstress (Tab GG-16 thru GG-17).

(3) Below are aircraft components that were not sent to laboratories for analysis but were analyzed by investigation team experts. Neither the engines nor landing gear were factors in the mishap.

a. Landing Gear Actuators Witness marks inside the actuators show that the nose landing gear actuators (NLG), as well as both main landing gear (MLG) actuators were in the extended position, indicating that the landing gear was up at the time of the impact (Tab J-5).

b. Engines Both J85 engines sustained catastrophic damage. All compressor blades were totally detached from the disk rotor, which is consistent with the engines operating at idle or above at the point of impact (Tab V-24.5). The left and right engine main fuel control throttle shafts were recovered from the mishap site in the idle or slightly above idle condition (Tab J-13).

b. Additional Testing

The Pitot Static System Tester is used to test flight instrumentation, such as altitude and airspeed. The tester last used on the MA was tested for calibration by the 412 MXS/MXMD, located at 308 East Popson Avenue, Edwards, CA, 93524-6655, with normal results (Tab U-101 thru U-102).

7. WEATHER

a. Forecast Weather

On 21 May 2009, the weather forecast for R-2508 predicted few clouds at 6,000 feet, few clouds at 15,000 feet, and scattered clouds at 25,000 feet. The term “few” is defined as less than 25% of sky coverage and scattered clouds means the clouds covered less than 50% of the sky. Visibility was unrestricted with winds out of the southwest at 18 knots, with gusts up to 25 knots. There were no forecasted hazards at the time of the mishap mission, but the weather forecast did include an advisory for possible light to occasional moderate turbulence from the surface up to 8,000 feet MSL starting at 1400L (Tab F-6):

b. Observed Weather

Observed weather at the time of the mishap reported few clouds at 6,000 feet and few clouds at 15,000 feet. Visibility was 85 miles with winds reported out of the southwest (from 240 degrees) at 11 knots, gusting to 19 knots (Tab F-14).

c. Conclusions

There was no evidence that weather contributed to the mishap.

8. CREW QUALIFICATIONS

a. Major Graziano (MP)

Prior to attending USAF Specialized Undergraduate Pilot Training (SUPT), the MP had acquired a private pilot license with a glider rating and 150 hours pilot-in-command time (Tab T-59 thru T-60). The MP attended SUPT at Laughlin AFB, Texas where he received his military pilot rating on 27 Sep 2001 (Tab T-47). He completed KC-135 copilot initial qualification at Altus AFB, Oklahoma in 2002. The MP flew two models of the KC-135 at Grand Forks AFB, North Dakota through early 2006 (Tabs G-8, T-26). During that time the MP returned to Altus AFB in 2004 to upgrade to aircraft commander and again in 2005 for instructor qualification (Tab T-22). The MP accumulated 1,776.5 hours in the KC-135 aircraft, including 135 hours of instructor time and 874.6 hours of combat time (Tab G-8 thru G-9). In 2006 the MP was reassigned to Beale AFB, California to fly the U-2 where he first qualified in the companion trainer T-38A aircraft (Tabs T-19 thru T-20, II-31).

The MP completed U-2 initial qualification in early 2007 followed by mission qualification that summer (Tab T-15 thru T-18). The MP attended Pilot Instructor Training (PIT) at Randolph AFB, Texas in 2008 for both his initial and instructor qualification in the T-38C aircraft (Tab T-9 thru T-12). The MP flew the U-2 through late 2008 accumulating 538.7 hours, including 299.0 hours of combat time (Tab G-8). Upon entry into TPS in late 2008, the MP continued to accumulate flight time in all three T-38 series aircraft (Tabs G-7, II-33). While at TPS, the MP also flew the C-12, F-16, HU-16, LJ-25 and TG-4 aircraft, accumulating 12.7, 5.6, 1.8, 3.8 and 1.5 hours in each, respectively. As of 21 May 2009 he had logged 263.5 hours in the T-38 (Tab G-7 thru G-9). Including simulator and student time, the MP had accumulated 2,895.0 total hours and 1,173.6 total combat hours in 170 combat sorties (Tab G-9).

The MP was a highly experienced and motivated pilot. While at SUPT, the MP maintained better than a 98% academic average. During both his KC-135 copilot and aircraft commander qualification training he achieved a 100% academic score. While assigned to the KC-135, the MP earned an "Exceptionally Qualified" (EQ) rating on each of his copilot, first periodic, aircraft commander and instructor upgrade flight evaluations (Tab T-22, T-25 thru T-28). An EQ is only awarded when the aircrew member has demonstrated exceptional skill and knowledge in all phases of the evaluation IAWAFI 11-202V2, *Aircrew Standardization/Evaluation Program,* Para. 5.2.11.4.1 (Tab BB-3 thru BB-4). While still a first lieutenant and with less than three years experience, the MP attended KC-135 aircraft commander training where he was a Distinguished Graduate. During his U-2 initial qualification training at Beale AFB, the MP achieved a score of 100% on the end-of-course academic exam. After 18 months as a U-2 aircraft commander, he was selected to upgrade to instructor and completed his U-2 instructor certification on 25 Jun 2008 (Tab G-32). In addition to maintaining a 96% academic average at Randolph AFB, the MP was the sole Distinguished Graduate in his T-38 PIT class where he also received an instructor qualification (Tab T-9 thru T-10). There is no record of the MP ever having received a downgrade or discrepancy on any flight evaluation (Tabs G-33, T-9 thru T-28).

Within the TPS curriculum, the MP had all prerequisites complete and was certified to fly this mission without IP supervision (Tabs G-12 thru G-15, T-57, O-50 thru O-53). This included a "Dynamics Demonstration" flight with an instructor test pilot (Tab G-12). At the time of the mishap, the MP was on probation for unsatisfactory performance on two attempts at the T-38 versus F-16 Photo/Safety Chase flight. Probation status was initiated on 8 May 2009 with an intended duration of 30 days (Tab T-51). He subsequently passed a progress check on the third Photo/Chase flight (Tab T-53, T-55). The Commandant of the Test Pilot School had flown with the MP and deemed him to always be very well prepared, in addition to considering him able to execute required maneuvers in the airplane (Tab V-3.2 thru V-3.3). The MP had flown three flights in the seven days prior to the mishap (Tab G-11). His 30-60-90 day flying history prior to the mishap is as follows (Tab G-3 thru G-4):

	Hours	Flights
30 days	18.3	15
60 days	34.6	27
90 days	41.9	34

Table 1. Major Graziano -- 90 Day Flight History
NOTE: Does not include mishap flight.

b. Major Jones (MN)

Prior to attending Joint Specialized Undergraduate Navigator Training, the MN had flown his father's personal light aircraft and was working on a private pilot's license (Tab V-1.13 thru V-1.14). The MN attended navigator training at Randolph AFB, Texas where he received his navigator rating on 2 Jun 2000 (Tab T-49). The MN completed navigator initial qualification in the RC-135 at Offutt AFB, Nebraska on 17 Sep 01. He flew on several models of the RC-135 aircraft at Offutt AFB through March 2006, advancing to the qualification of Instructor Navigator (IN) and Evaluator Navigator (EN) (Tabs G-35, T-38 thru T-39). He also flew on one mission in the E-3 aircraft, accumulating 5.9 hours (Tab G-23). In April 2006, the MN was reassigned to Det 2, 645th Aeronautical Systems Squadron, Greenville, Texas to fly the RC-135 and NC-135 as a senior flight test navigator through November 2008 (Tab G-22 thru G-23). While there, the MN also flew in the PC-12, U-28A and C-40 aircraft, accumulating 4.0, 8.7 and 3.5 hours, respectively. The MN has accumulated 1,498.3 hours in the RC-135 and NC-135 aircraft, including 386.3 hours of instructor time and 596.8 hours of combat time. Upon entry into TPS in late 2008, the MN also flew in the C-12, C-172, F-16, HU-16, LJ-25, and T-38 aircraft, accumulating 11.1, 7.6, 9.7, 1.6, 5.5 and 8.9 hours in each, respectively (Tab G-21 thru G-23). Including simulator and student time, the MN had accumulated 1804.4 total hours and 596.8 total combat hours in 55 combat sorties (Tab G-23).

The MN is a highly experienced navigator. While assigned to the RC-135, the MN earned an “Exceptionally Qualified” (EQ) rating on his instructor upgrade flight evaluation (Tab T-38 thru T-39). There is no record of the MN ever having received a downgrade or discrepancy on any flight evaluation that would have been a contributing factor in this mishap (Tab T-29 thru T-46).

Within the TPS curriculum, the MN had all prerequisites complete and was certified to fly this mission without instructor supervision. This included a “Dynamics Demonstration” flight with an instructor test pilot (Tabs G-26 thru G-29, O-50 thru O-53). The MN had flown two missions in the seven days prior to the mishap (Tab G-25). His 30-60-90 day flying history prior to the mishap is as follows (Tab G-18):

	Hours	Flights
30 days	16.0	11
60 days	26.1	18
90 days	36.8	26

Table 2. Major Jones -- 90 Day Flight History
NOTE: Does not include mishap flight.

9. MEDICAL

a. Qualifications

The AIB’s medical advisor performed a complete review of the medical and dental records of the MP and MN. 72-hour and 14-day histories of the MP, MN and associated maintenance crew members were taken and reviewed (Tab T-5). The MP’s histories were reconstructed as thoroughly as possible through witness testimony. The MP and MN were in good health and had no recent performance-limiting illnesses prior to the mishap (Tab T-7).

The MP was medically qualified for flight duty without medical restrictions or waivers at the time of the accident. The MP’s most recent Periodic Health Assessment (PHA) was accomplished on 22 October 2008 at Beale AFB. At that time he was medically qualified for

Flying Class II flight duties IAW AFI 48-123 V3, *Medical Examinations and Standards/Flying and Special Operational Duty* (Tabs T-7, BB-57 thru BB-58). He had an initial medical clearance at Edwards AFB performed on 18 December 2008 and was provided with a current AF Form 1042, *Medical Recommendation for Flying or Special Operational Duty*. The MP displayed no physical or medical limitations prior to the mishap (Tab T-7).

The MN was medically qualified for flight duty at his most recent PHA on 28 October 2008 (Tab T-7). His initial medical clearance for Edwards AFB was completed on 23 December 2008 and no additional medical concerns or disqualifying conditions were recorded (Tab T-7). A current AF Form 1042 Medical *Recommendation for Flying or Special Operational Duty* was present in his medical records from that appointment. The MN displayed no physical or medical limitations prior to the mishap.

A review of the Aeromedical Information Management Waiver Tracking System (AIMWTS) showed that the MP and MN were not on any medical waivers. Neither the MP nor the MN were on any medications at the time of the mishap. There was no evidence that any medical condition contributed to this mishap.

b. Health

The MN successfully ejected from the MA at high speeds and an altitude above 10,000 feet (Tab H-16). During the high speed ejection he suffered multiple injuries. He was initially treated by Edwards AFB emergency medical personnel and then immediately airlifted to Kern Medical Center, Bakersfield, California (Tab T-5). On 26 May 2009, after undergoing initial surgical stabilization at Kern Medical Center, he was transferred to Naval Medical Center San Diego, San Diego, California for continued treatment. At the time of this AIB report he was continuing to undergo therapy with multiple surgeries planned in the future (Tab T-5).

c. Pathology

The MP's death was instantaneous due to blunt force trauma (Tab X-3).

d. Toxicology

Immediately following the mishap, in accordance with AFI 91-204, *Safety Investigations and Reports*, command directed toxicology testing for all personnel involved in the flight and the launch of the MA was performed (Tab BB-61). The Armed Forces Institute of Pathology (AFIP) performed the testing for carbon monoxide, ethanol levels, and illicit drugs (Tab T-5).

Testing for carbon monoxide was performed on the MN and associated maintenance crew members and found to be normal. Testing was not performed on the MP (Tab T-5). AFIP examined samples from the MP, MN, and associated maintenance crew members for the presence of ethanol. All testing was negative (Tab T-5).

Furthermore, AFIP screened samples from the MP, MN, and maintenance crew members for illegal drugs. No illegal drugs were detected in the MP or associated maintenance crew members. Morphine was administered to the MN following the incident for pain control, and the presence of morphine in the urine is not indicative of prior, inappropriate, or illegal use (Tab T-5). Morphine was detected in the MN's urine by immunoassay and confirmed by gas chromatography. No morphine was detected in his blood at a quantification limit of 0.05 mg/L using gas chromatography/mass spectrometry (Tab T-5).

e. Lifestyle

Witness testimonies, as well as a review of the 72-hour and 14-day histories of the MP, MN, and associated maintenance crew members, revealed no lifestyle factors, including unusual habits, behaviors or stresses which were causal or substantially contributory to the mishap (Tabs T-5, T-7, V-1.12, V-3.4, V-4.4).

f. Crew Rest and Crew Duty Time

Air Force Instructions require aircrew have proper "crew rest," as defined in AFI 11-202, Volume 3, *General Flight Rules*, 5 April 2006, prior to performing in-flight duties (Tab BB-6). The purpose of crew rest is to ensure the aircrew member is adequately rested before performing flight or flight related duties. AFI 11-202 defines normal crew rest as a minimum 12-hour non-duty period before the flight duty period (FDP) begins that gives the individual the opportunity to sleep. During this time, an aircrew member may participate in meals, transportation or rest as long as he or she has the opportunity for at least eight hours of uninterrupted sleep. FDP is the period that starts when an aircrew member reports for a mission, briefing, or other official duty and ends when engines are shut down at the end of the mission. (Tab BB-7)

A review of the duty cycles and 72-hour and 14-day histories of the MP and MN leading up to the mishap indicated that both had adequate crew rest and were within the authorized crew duty limitations when the mishap occurred (Tab T-5). The Operational Risk Management (ORM) sheet for that mission had crew rest marked as fair (Tab K-7). The MN stated that he was adequately rested at the time of the mishap (Tab V-1.12). The MP's duty cycle and history was determined through witness interviews and was deemed complete enough to rule out fatigue or stress as substantially contributing to the mishap (Tabs T-5, V-1.12). Fatigue was not a factor in this mishap.

10. OPERATIONS AND SUPERVISION

a. Operations

It was determined that operations within the USAF Test Pilot School were not a factor in this mishap. The USAFTPS is a diverse organization consisting of highly experienced active duty and reserve Air Force, active duty Navy, and government civilian test pilots, test navigators, test weapons systems operators, and flight test engineers. The instructor corps at the TPS is comprised mainly of graduates of the various military test pilot schools, and is supplemented with a variety of experts with extensive experience in various engineering disciplines and the curriculum aircraft used by the school. The students attending the school are selected by a board of officers based upon their superior job performance, demonstrated flying abilities, academic excellence, and operational experiences.

New classes of students arrive in July and January of each year and run for approximately 50 weeks, with a two week break in the middle of the academic year. Typical class size is generally composed of approximately 20 students, with a mix of pilots, navigators, and flight test engineers (Tab V-3.2). Due to the rigorous syllabus, students form tight bonds with their fellow classmates and rely heavily on the expertise of their peers as the class progresses through the four phases of the curriculum.

As with any formal school curriculum, the timeline of student progression is closely monitored and can have a distinct impact on the operations tempo within the unit. At the time of this mishap, the MP and MN were still in the first six months of their academic year and their class was referred to as the *Junior* class. Early in the academic year, the junior class was approximately two weeks behind the planned timeline for graduation. This resulted in the junior class working harder than normal in the weeks preceding the mishap, but they were showing a positive trend towards being back on the timeline (Tab V-7.4). Regardless, the TPS curriculum is very demanding and requires a considerable amount of student effort in order to succeed.

The TPS has a comprehensive and detailed Operational Risk Management (ORM) program. The ORM program is used in preparation for every TPS flight. The program is designed to detect factors such as lack of sleep, sickness, personal issues, etc. that could potentially affect the crew's ability to safely fly the mission. Identifying factors that may increase the level of operational risk of a particular mission causes the ORM assessment to change from green to yellow to red. As the level of risk increases to yellow or red, supervisory personnel must be informed of elevated factors and may subsequently impose additional requirements before making a final determination whether a crew is safe to fly. For this particular mission, the MC completed the requisite ORM worksheet with an overall assessment of "Green" (Tab K-7).

b. Supervision

It was determined that supervision within the USAF Test Pilot School was not a factor in this mishap. Supervision of the students at TPS is accomplished through a variety of methods. Each class has an appointed Senior Ranking Officer (SRO) who serves as the focal point for addressing student issues to the chain of command. Each student has an assigned Personal Faculty Advisor (PFA) who is responsible for monitoring student progression through audits of their gradebooks and through informal counseling sessions with the students (Tab V-7.5).

The management of the USAFTPS is overseen by the Commandant and Deputy Commandant. Flying operations fall under the responsibility of the Director of Operations (DO) and the Assistant Director of Operations (ADO). Specific daily missions are managed by the Operations Supervisor (OpsSup) who works in parallel with the Operations Duty Officer (ODO), all of whom are qualified aircrew members (rated or non-rated) of the TPS staff (Tab O-18 thru O-19).

With respect to supervision of mission events, students who are scheduled to fly "crew solo" missions are required to create detailed mission profiles and must brief their mission to an instructor pilot (IP), qualified in the aircraft type that the student mission will be flown in (Tab O-30). Crew solo missions are those where two students will fly a flight without an instructor pilot in their aircraft. The flight cards must also be reviewed and signed by an aircraft specific IP, or in their absence, the DO, Chief Test Pilot, or ADO (Tab O-20). This signature requirement allows the instructors an additional opportunity to share flight test techniques, review operational limits, and discuss overall mission profiles with the students before they execute the mission. On the day of the mishap mission, the MP briefed the mission profile to a T-38 IP and received the IP's signature on the flight card after thoroughly discussing each aspect of the mission (Tabs K-5, V-8.2)

11. HUMAN FACTORS ANALYSIS

A human factor is not merely an individual's response or action during an event or task; it is how features of people's tools, tasks and working environment systemically influence human performance. As described by James Reason (1990), accidents and injuries are the result of both latent and active failures (Tab BB-62). Latent failures are the pre-conditions that define an atmosphere that allows a mishap to occur. They include any failed or absent organizational factors, training programs, supervision, and/or defenses (Tab BB-62). Active failures are the unsafe acts that directly lead to the mishap. They are the immediate preceding causal event of most mishaps, and are typically the focus of most accident investigation boards (Tab BB-62). However, the Swiss Cheese Model described by Reason (as shown below from AFI 91-204, *Safety Investigations and Reports,* Attachment 5) clearly demonstrates how a thorough accident investigation should clearly identify latent conditions to identify where and how risk mitigation strategies failed (Tab BB-63).

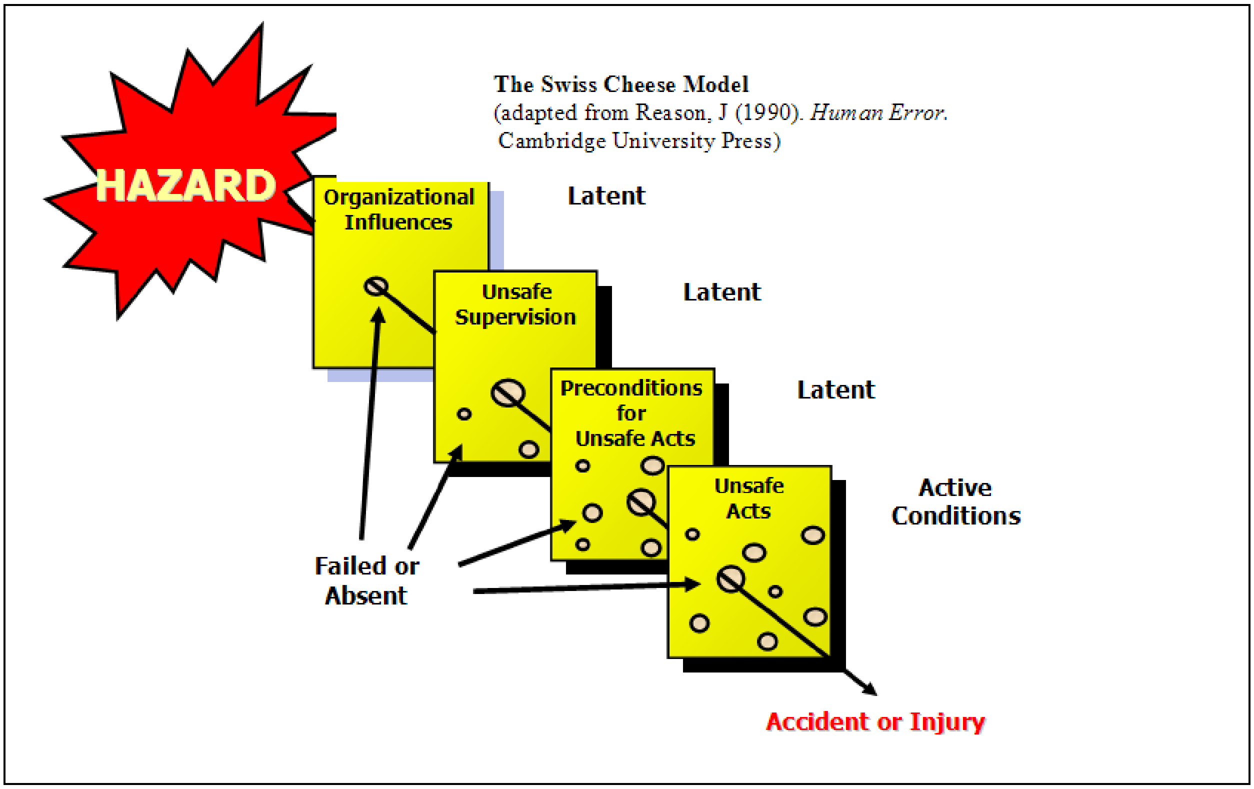


Figure 3. The Swiss Cheese Model

The board considered all of the environmental and individual human factor elements contained in Air Force Instruction 91-204, *Safety Investigations and Reports*, Attachment 5, Department of Defense Human Factors Analysis and Classification System (DOD HFACS), and analyzed them to identify potentially relevant factors that may have contributed to this mishap. DOD HFACS categorizes human factors into four classes: Organizational Influences, Unsafe Supervision, Preconditions for Unsafe Acts, and Unsafe Acts (Tab BB-63). All four categories were carefully reviewed by the accident investigation board for any applicable contributing or causal factors.

a. Preconditions for Unsafe Acts

"Preconditions are factors in a mishap if active and/or latent preconditions such as conditions of the operators, environmental or personnel factors affect practices, conditions or actions of individuals and result in human error or an unsafe situation" (Tab BB-66). No cognitive, behavioral, physiological, technological, environmental, perceptional, or personal human factors on the part of the MC were identified as contributing to the mishap. The failure of the MP to eject was likely due to an incapacitating event (i.e., physiological reaction to g-forces, injury); however, the incapacitation of the MP did not cause or contribute to the mishap as the aircraft was already in an unrecoverable hard left rudder configuration (Tab J-15). The MN also suffered a significant physiologic event (physiological reaction to g-forces) during the initiation of the mishap sequence resulting in spatial disorientation (Tab V-1.2). However, this was not causal or contributory to the mishap, since the MA was in an unrecoverable hard left rudder configuration.

Cross-monitoring performance is a factor when crew or team members failed to monitor, assist or back-up each other's actions and decisions (Tab BB-67). The MA was in a hard left rudder position at impact, a configuration that the Accident Investigation Board found was most likely the result of an improperly secured bolt in the rudder operating system (Tabs J-15, V-19.4). Although the specific identification of the unsecured bolt and the reason for the improper installation could not be determined (i.e., whether it was due to inattention, distraction, checklist error, or procedural error), cross-monitoring of aircraft maintenance mechanics' work should have prevented improper installation of a bolt. The last documented maintenance actions on the critical components of the MA rudder system were during the Phase 1 major 900-hour inspection (Tab U-43 thru U-69). At that time, a proper rigging of the rudder system would have required three individuals to inspect the work to ensure the rudder system had been secured properly: the aircraft mechanic that performed the work, an inspector, and a quality assurance inspector (Tabs BB-56, BB-86, BB-88, V-10.7, V-17.4).

As explained in detail in the maintenance section, the 412 MXG performs the T-38 Quality Verification Inspection (QVI) differently than it does on other airframes (Tab V-18.6). For T-38's undergoing phase maintenance at Edwards AFB, the QVI on each section is performed as soon as that section is completed (as opposed to waiting until the entire plane is ready for inspection). This means the panels of the aircraft remain off and maintenance members continue to work on the aircraft after the QVI of a specific section (i.e. wings, landing gear, cockpit) has been completed (Tab V-18.4). Therefore, there is the potential that subsequent maintenance errors could occur, without inspection, if work is performed near or around a flight system after it has been evaluated by QA. The Accident Investigation Board determined there was significant evidence to suggest that during the October 2008 to January 2009 phase maintenance performed on the MA either the QA inspections were performed inadequately to identify any improperly secured bolt or that the T-38 QVI policy allowed an error to be made after the QA inspection.

b. Unsafe Acts

Acts are the active failures most closely tied to a mishap. They are defined in AFI 91-204 as active failures or actions committed by the operator that result in human error or unsafe operation (Tab BB-64). No acts by the MP or MN were identified by the Accident Investigation Board as significantly causal or contributory to the mishap. All actions taken by the MN in attempting to recover the aircraft and ejecting from the aircraft were appropriate. When the MN started to become aware of his surroundings, he could not see, was unable to communicate with the MP, and was unable to feel the aircraft respond to flight control inputs that he made (Tab V-1.3). Although he had felt earlier that they were "knocked around," he was unable to determine aircraft attitude or heading and did not feel any acceleration forces. He did remember the last input was a definitive nose down push towards the ground (Tab V-1.5). The aerodynamic engineering analysis reported the MA experienced rapid oscillating forces in all axes followed by a dampening corkscrew until ground impact. Given the high descent rate of the aircraft in the 39-degree dive, any further attempt to control the aircraft or delay in ejection would have clearly resulted in a decreased chance of survival (Tab V-20.4)

Violation - Based on Risk Assessment is a factor when the consequence/risk of violating published procedures was recognized, consciously assessed and honestly determined by the individual, crew or team to be the best course of action. Routine "work-arounds" and unofficial procedures that are accepted by the community as necessary for operations are also captured under this code (Tab BB-65). AFI 21-101, AFMC Sup 1, paragraph 3.9.12, required that all maintenance work be documented in IMDS or maintenance forms by "the individual completing the task" (BB-51). A Work Lead reported that IMDS would only allow them to sign off work if all required people to sign off the work are from the same maintenance unit; a phase maintainer cannot sign off work that they performed with an AMU crew chief (Tab V-16.2). A common "work-around" is for a phase Work Lead to substitute their name in IMDS for the actual AMU crew chief that performed the work (Tab V-16.3). Although this allows the work to be captured and documented in IMDS, it prevents an individual from conducting an accurate retrospective review of who completed the work. Considering it is 412 MXG practice to destroy 781As after three months, the Accident Investigation Board was unable to determine the identity of and interview the aircraft maintenance mechanic and inspector who last worked on and examined the rudder system. The "work-around" of the phase Work Lead documenting his name in the place of the mechanic actually performing the work could not be ruled as definitively contributing or causal, but it did prevent the Accident Investigation Board from interviewing the individual who last worked on the rudder system.

c. Unsafe Supervision

The Accident Investigation Board discovered multiple problems with maintenance training documentation and maintenance procedures. These include a lack of documentation, lack of training, and insufficient supervisory oversight of the training process.

Local Training Issues/Programs are a factor when one-time or recurrent training programs, upgrade programs, transition programs or any other local training is inadequate or unavailable and thus creates an unsafe situation (Tab BB-68). Local training issues are a factor in the mishap because the Accident Investigation Board found flaws in the implementation and documentation of the local training process. After interviewing multiple aircraft maintenance mechanics, a 412 MXS Work Lead, the 912 AMXS AMU Chief, and the 412 MXG Chief of the Maintenance Training Division, it was clear that a discrepancy existed between maintenance supervisors' and maintenance crews' understanding of proper training requirements for working on different aircraft (Tab V-11.5, V-12.6, V-13.2, V-14.4, V-16.7, V-17.9). As explained in the maintenance section of this report, most aircraft mechanics were not aware of training requirements. The Work Lead and aircraft mechanics consistently testified that they are authorized to perform work based on their position description or prior experience. The Maintenance Group Training Manager and the AMU chief, however, testified that the official training plan is the one described above (the one set forth by AFI 21-101 and the CMTP) (Tab V-13.2, V-14.3). Specifically, if the aircraft maintenance mechanic was not signed off on a task in their training record they were not to perform it without a qualified person (i.e., one who is properly signed off on the task) present (Tab V-14.7).

A review of the training records for the interviewed aircraft maintenance mechanics revealed multiple deficiencies (Tab HH-1 thru HH-169). One aircraft mechanic testified that he had performed an unsupervised inspection of the MA, but a review of his T-38 training record revealed he had not received the training for, nor was he qualified to accomplish the inspections that he subsequently signed off. (Tabs V-9.5, HH-81 thru HH-99) From the testimony and training records of the aircraft mechanics, it was clear that some training requirements had not been met or not been documented. It must be made clear that in the vast majority of cases the aircraft maintenance mechanic had probably received appropriate training in the past (almost all civilian employees interviewed had prior military service, most in the Air Force as upper level maintenance crew). However, inadequate documentation standards and the lack of emphasis placed on ensuring individuals were receiving and documenting the required training made verification impossible (Tab V-9.7, V-10.6, V-16.8). The lack of an appropriate training method, largely derived from a failure to follow the HPO waiver from AFI 21-101 requirements, led to maintenance crews performing work without the proper training documentation.

Supervision - Discipline Enforcement is a factor when unit (organizational) and operating rules have not been enforced by the normally constituted authority (Tab BB-69). Supervision discipline is a factor in the mishap because the Accident Investigation Board found a significant lack of training procedure enforcement during the course of this investigation. For example, a T-38 maintainer hired as a Wage Grade 12 (WG-12) with 10 years of experience had only 61% of his Job Qualification Standard tasks signed off. He testified that he worked on the MA rudder pedal rig under the supervision of someone who was trained. He had received no documented training since April 2008; prior to that, his last documented training was November 2007 (Tabs V-15.4, HH-123 thru HH-152).

The Accident Investigation Board was unable to find any maintenance member authorized IAW the CMTP and AFI 21-101 to rig the T-38 rudder system. The CMTP designates T-38 flight control rigging a “special certification item” (Tab V-24.3). Special certification items are procedures that require special training and proficiency demonstration (Tab BB-77). The 412 MXG has a Special Certification Roster that documents individuals trained and certified to perform each special certification item (Tab V-25.1). However, the 412 MXG special certification roster does not list T-38 flight control or rudder rigging, and no other documentation existed that would allow anyone in the maintenance group to perform that work (Tab V-25.1). The Work Lead interviewed stated that he attended a three-week class for rigging that was given at Edwards AFB by an off-base instructor. However, when the class was over he and the other attendees were not provided certifications to perform rigging, because the instructor had not been through the “train the trainer” course to make him a certified trainer, and thus could not certify anyone who attended the class (Tab V-16.9).

Although the documentation of training received was problematic, the aircraft maintenance mechanics and a Work Lead offered consistent testimony that they were qualified because of the job description of the position they were hired for (Tab V-10.5, V-11.5, V-16.7). Further questioning revealed a general and pervasive unfamiliarity with what their training record contained and what they were authorized to perform (Tab V-9.6, V-10.5, V-11.5, V-16.7). Some aircraft maintenance mechanics and a Work Lead had the perception that they were hired based on training they have received in the past, and were therefore qualified to perform any task they were assigned (Tab V-9.6, V-10.5, V-11.5, V-16.7). The 412 MXG failed to ensure aircraft mechanics were adequately trained and that the individuals fully understood their training status. Instead, the Accident Investigation Board found that the Work Lead relied upon general credibility, reputation and “comfort” (Tab V-16.8). It is apparent that maintenance crewmembers were not aware of training requirements, and therefore did not provide self-monitoring of the tasks that they were authorized to perform. The Accident Investigation Board determined that insufficient supervisory oversight and lack of discipline of the training process was a factor in this mishap.

d. Organizational Influences

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 (Tab BB-70).

Unit/Organizational Values/Culture is a factor when explicit/implicit actions, statements or attitudes of unit leadership set unit/organizational values (culture) that allow an environment where unsafe mission demands or pressures exist (Tab BB-71). Unit culture is a factor in this mishap because the mid-level maintenance leadership and supervisors gave the Work Lead and aircraft mechanics the impression that accurate training and documentation of that training is not necessary to perform their job; they failed to enforce the standards. Multiple aircraft maintenance mechanics and a Work Lead testified that they were under the impression that they were hired as general aircraft maintainers and were therefore qualified to perform work on any assigned aircraft (Tab V-9.6, V-10.5, V-11.5, V-16.7). A pervasive inattention to, and lack of concern for, training practices and documentation was found to exist at the mechanic and work lead levels. Regardless of how this impression was fostered or allowed to persist, it is clear that the leadership and supervisors of the 412 MXG failed to convey an appropriate understanding and attitude toward training practices. There was a clear gap in understanding of training policies between leadership/supervisors and maintenance crews/work leads. Whether implicit or explicit, the mid-level leadership and supervisors in the 412 MXG conveyed a disturbing lack of understanding of, or concern for, proper training procedures as outlined in AFI 21-101 and the CMTP to aircraft maintenance mechanics and the Work Lead.

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Primary Operation Directives and Publications

(1) Air Force Instruction 11-202 Volume 2, 8 December 2006, Incorporating Change 1, 19 September 2007, Air Force Materiel Command Supplement, 6 March 2007, Incorporating Change 1, 19 December 2007, Flying Operations, *Aircrew Standardization/Evaluation Program*
(2) Air Force Instruction 11-202, Volume 3, 5 April 2006, Air Force Materiel Command Supplement, 28 April 2007, Incorporating Change 1, 21 August 2008, Flying Operations, *General Flight Rules*
(3) Air Force Instruction 11-401, Air Force Materiel Command Supplement 1, 2 June 2005, *Aviation Management*
(4) 1T-38A-1, *Flight Manual*, 1 August 2005, 1T-38A-ISS-186, Change 1, 1 January 2006

b. Maintenance Directives and Publications

(1) Air Force Instruction 21-101, 29 JUNE 2006, Air Force Materiel Command Supplement, 14 December 2007, *Maintenance Aircraft and Equipment, Maintenance Management*
(2) 412th MXG *Exceptions Document* to Air Force Instruction 21-101, Air Force Materiel Command Supplement
(3) 412 MXG Civilian Master Training Plan
(4) 412 MXG Quality Assurance Evaluation and Inspection Plan
(5) 1T-38A-6WC-3, *Inspection Work Cards*, 31 May 2007, Change 6, 15 March 2009

c. Known or Suspected Deviations from Directives or Publications

AFI 21-101, paragraph 3.9.12, states that any mechanic performing a task should ensure MIS (Maintenance Information System) is documented by the individual completing the task (Tab BB-51). (IMDS is a component of MIS.) A 412 MXS Work Lead testified that, when entering data into IMDS, he commonly substituted his name for the AMU crew chief that actually performed the maintenance task. Although this allowed him to sign off the task in IMDS (and by testimony is the only way they are able to sign off tasks when an AMU crew chief performs work in their shop), it is technically in violation of AFI 21-101 and prevents the ability to determine later who actually performed the action.

The 412 MXG Civilian Master Training Plan stated the Work Leads will "Provide the Maintenance Training Division a monthly report on each employee in training. Report will include number of tasks required for full performance in the position, number of tasks completed, and number of tasks requiring training" (Tabs V-13.15 paragraph 10.5). A review of multiple aircraft mechanics training records revealed a monthly review was not being documented (Tabs V-14.23, HH-3, HH-35, HH-57, HH-79, HH-101, HH-123, HH-153). Additionally, the monthly report given to the Maintenance Training Division gives only aggregate numbers and does not satisfy the letter or intent of the CMTP (Tab JJ-3 thru JJ-7).

The 412 MXG Civilian Master Training Plan lists the T-38 Flight Control Rig as a special certification item in Appendix C, "Master Special Certification Roster," Course Code 900705 (Tab V-24.1, V-24.3). However, the published 412 MXG Special Certification Roster, which lists mechanics actually signed off to perform the various special certification items, did not contain "T-38 Flight Control Rig" as a special certification item (Tab V-25.1). Therefore, no mechanic in the 412 MXG was documented as authorized to perform the T-38 Flight Control Rig Tabs V-13.14, paragraph 10.4; V-13.15, paragraph 11.2; and V-13.16, paragraph 12).

In addition to the lack of proper certification of any 412 MXG mechanics to perform the T-38 Flight Control Rig, one mechanic was shown to have performed an unsupervised inspection that he was not authorized to perform (Tabs V-13.15 paragraph 10.6, V-9.3, HH-79 thru HH-100). However, the lack of emphasis on documentation and training led the Accident Investigation Board to suspect that it is likely other maintenance tasks have been performed without the proper training documentation (Tab V-13.13 thru 13.16, paragraphs 10 thru 12).

13. MEDIA INVOLVEMENT

Following the mishap, media interest related to the incident was high. Local and national media outlets immediately reported on the mishap. The 95 ABW Public Affairs office posted articles pertaining to the mishap on the base website (Tab CC-3 thru CC-5). Additionally, an article was posted on the Arlington National Cemetery website as a tribute to the MP's life and accomplishments (Tab CC-7 thru CC-13).

14. ADDITIONAL AREAS OF CONCERN

None.

10 September 2009

CURTIS M. BEDKE, Major General, USAF
President, Accident Investigation Board

STATEMENT OF OPINION
T-38A, T/N 68-8153, EDWARDS AFB
21 May 2009

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

1. OPINION SUMMARY

I find clear and convincing evidence that the cause of this mishap was a failure of the rudder operating mechanism, which disconnected the flight controls from the rudder actuators and caused the rudder to deflect 30 degrees left. This hardover rudder induced an uncontrollable yaw and a resulting roll, causing the aircraft to depart controlled flight. This condition is unrecoverable in the T-38.

There are two possible causes of the rudder operating mechanism failure: either a structural break in a critical component or bolt, or a maintenance error in which a nut or cotter pin did not properly secure a bolt connecting two critical components.

Based on a review of physical evidence, expert testimony from T-38 mechanical systems engineers, and local maintenance practices, I find substantial evidence to conclude that it is highly likely that due to a maintenance error, one of the seven bolts securing the rudder operating mechanism "Critical Safety Items" was improperly secured. The unsecured bolt worked its way free over an unknown period of time, eventually backing out of its location sufficiently to allow the two critical components to separate, thus disconnecting the flight controls from the rudder actuators. The MP's properly-executed zero-to-negative-g input was the final—but not causal—condition that allowed the bolt to finally work free, disconnecting the rudder's controls. The pilot-induced pitch down, followed immediately by a non-pilot-induced rapid yaw and roll, incapacitated the MP, from which he never recovered.

2. BACKGROUND

On 21 May 2009, at 1239 local time (L), a T-38A aircraft assigned to the 412th Test Wing, Edwards AFB, tail number 68-8153 (MA), departed Edwards AFB on a test training mission. On board were two students enrolled in the USAF Test Pilot School (USAFTPS): a student test pilot in the front seat, and a student test navigator in the rear seat. The aircrew was taking flight test data for analysis and reporting, in support of the Flying Qualities phase of the USAFTPS curriculum.

The mishap aircrew had received academic classroom instruction in the theory and conduct of the mission. Additionally, each student had received a Dynamics Demonstration flight with an instructor test pilot. The MP had received in-flight instruction and demonstration of the procedures and techniques, and had flown much of the profile himself under the eye of the instructor test pilot. The mishap Navigator (MN), not being a pilot, had nonetheless also flown a demonstration flight, during which the instructor test pilot performed the maneuvers and the MN practiced observing and recording the test data.

Aircrew qualifications, flying proficiency, training, mission preparation, crew rest, 72-hour histories, and weather were normal and unremarkable. Both aircrew were highly skilled and motivated.

The MP was a KC-135 instructor pilot who had then received a coveted U-2 assignment. In that latter assignment he had become both a U-2 instructor pilot and a T-38 instructor pilot. He had 2,895.0 flying hours, including 1,173.6 combat flying hours in 170 combat sorties. The MP was on flying probation due to his failure of a dissimilar chase sortie (flying the T-38 in formation with an F-16), and his failure on the repeat sortie. Nonetheless, he had subsequently passed his progress check; the Test Pilot School's Commandant had flown with him and found him to be always very well prepared, and considered him to execute the required maneuvers very well in the airplane. I determined his flying probation not to be a factor in this mishap.

The MN was an RC-135 instructor navigator with 1,804.4 flying hours, including 596.8 combat flying hours in 55 combat sorties. Additionally, he had flown his father's personal light aircraft and was working on a private pilot license. He had flown in the T-38, F-16, C-12, Cessna 172, Learjet 25, and HU-16 Albatross at USAFTPS.

Ground operations for the mishap flight were unremarkable. The MP used a hand-held force gage to determine the control stick break-out forces and to reinforce familiarity with the various amounts of pressure on the stick—a standard test technique. The MA was airborne at 1239L, climbing to 20,000 feet and 0.9 indicated mach number (IMN). The aircrew proceeded through the test profile, performing a series of test maneuvers and recording the data for each. As the flight was a Longitudinal Static Stability data profile, all maneuvers focused on the handling qualities of the airplane, specifically the pitch sensitivity by making fore-and-aft control stick inputs. The pilot would use the force gage to calibrate control stick "breakout" forces in stabilized level flight. The last series of points accomplished were a series of "Pushover" data points. The pilot would stabilize the airplane for 1 "g" level flight, on conditions, and then push the nose over to achieve various stable "g" loadings: 0.7g, then 0.5g, and finally 0.0g conditions.

During this series of "Pushover" data points, the MP's hand-held force gage was either unsecured within the front cockpit, or broke free from its secure location during the 0.0g data point, and floated up to rest on the ledge above and behind the MP's ejection seat, against the Plexiglas separating the two cockpits and easily visible to the MN.

Upon completion of the 0.0g data point, the MP told the MN he was going to attempt to get the force gage to float back forward to retrieve it (a common technique). The MN acknowledged with an "okay…" and almost immediately after this felt a sudden sharp and unexpected nose down (negative "g") onset, and saw the MP rising up, hitting his helmet on the canopy. The MN experienced either a total or near-total loss of consciousness. He does not know how long he was "out" or disoriented.

Upon regaining awareness, the MN could see only white, due to physiological effects most likely caused by some combination of negative, positive and/or yaw/roll "g" forces. The MN made repeated calls to the MP but received no response. The MN took the controls, but was unable to feel any MP inputs to the controls, nor any aircraft response to the MN's stick inputs. The MN could not sense any aircraft movement or "g" forces in any direction. Temporarily blinded, unable to communicate or get any sense of the MP's status, unable to make any effective control inputs, and remembering that the last known input to the aircraft had been a perceived sharp nose-down input, the MN called for the MP to "bailout, bailout, bailout" and then ejected from the aircraft. He believes he used only his right hand to eject, and does not recall the position of his left hand during the ejection sequence. All egress equipment worked properly, but the MN sustained serious injuries due to the out-of-envelope ejection (rolling and yawing at high speed).

The MP did not initiate ejection and died upon impact.

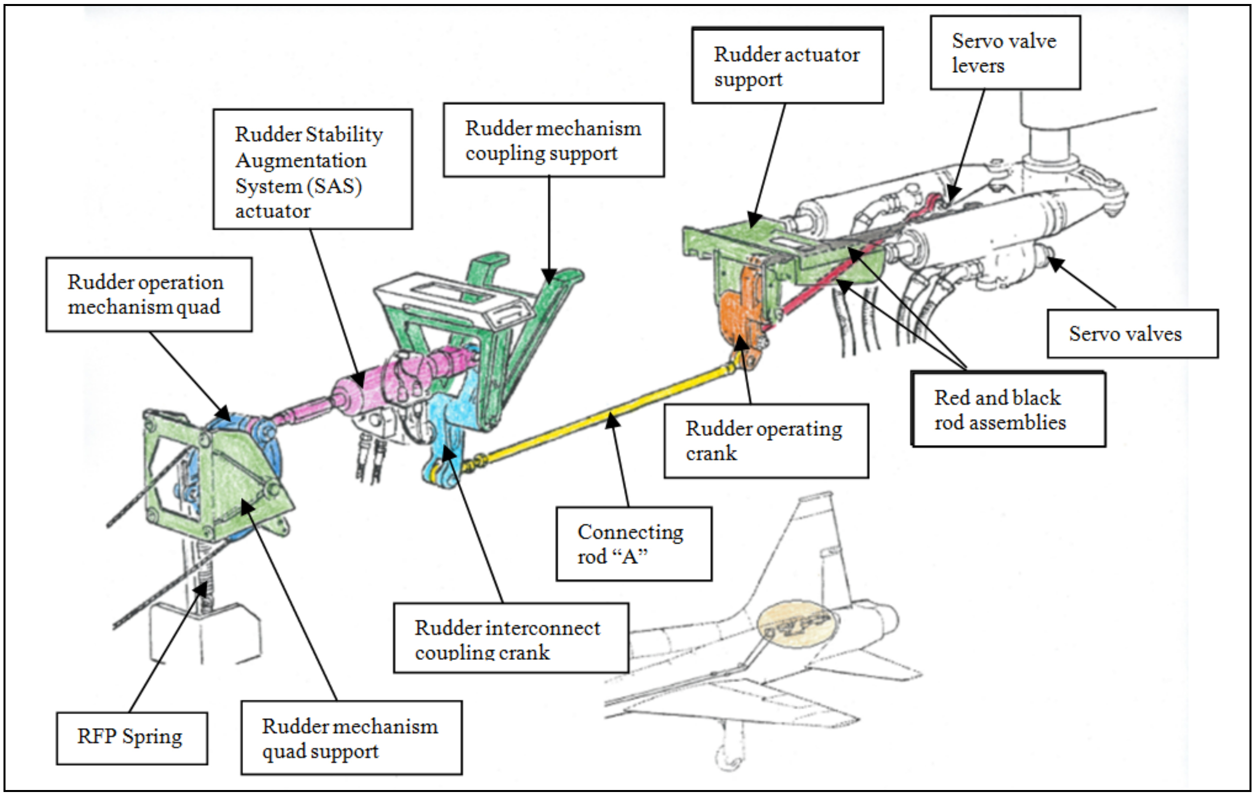
At the time of the incident, the MA configuration was gear and flaps up, with ailerons, horizontal stabilizer and rudder neutral and stabilized for level flight, and throttles set to maintain 0.90 IMN level flight at 20,000 feet Pressure Altitude. The MN remembers during his attempts to communicate with the MP and control the aircraft that he moved the throttles back toward the idle position. Site recovery operations indicated at impact the MA fuel controls were at or near idle, gear and flaps were up, ailerons and horizontal stabilizer were neutral, and the rudder was 30 degrees left full limit.

3. DISCUSSION OF OPINION

a. Cause

I find clear and convincing evidence that the cause of this mishap was a failure of the rudder operating mechanism, which disconnected the flight controls from the rudder actuators and caused the rudder to deflect 30 degrees left. This hardover rudder induced an uncontrollable yaw and a resulting roll, causing the aircraft to depart controlled flight. This condition is unrecoverable in the T-38.

Based on analysis of the rudder actuators/control system, expert testimony from T-38 mechanical systems engineers confirms that the positions of both rudder actuators show the rudder was already at 30 degrees left full limit prior to impact, and not as a result of the impact. Due to the design of the rudder operating mechanism, the normal in-flight limit is 6 degrees; the only way to induce a 30 degree hardover rudder is to have a failure of a rudder critical safety item (see diagram, next page), to include the portion of the system between the rudder force producer spring and the rudder operating crank.



Rudder Operating Mechanism Critical Safety Items (CSI)

There are two possible causes of a rudder operating mechanism failure: either a structural break in a critical component or bolt, or a maintenance error in which a nut or cotter pin did not properly secure a bolt connecting two critical components.

According to the T-38 mechanical systems engineering analysis of the margins of safety and historical replacement data on the structural components, the engineering opinion is that it is highly unlikely that mechanical fatigue failure was the cause. It is highly likely, in the opinion of the engineer, that a maintenance error allowed an improperly secured nut to become unseated, disconnecting the flight controls from the rudder actuators.

I find substantial evidence, based on a review of physical evidence, the expert statement from the T-38 mechanical systems engineer, and local maintenance practices (addressed in "Contributing Factors," below), to conclude that it is highly likely that due to a maintenance error, one of the seven bolts securing the rudder operating mechanism "Critical Safety Items" was improperly secured. The unsecured bolt worked its way free over an unknown period of time, eventually backing out of its location sufficiently to allow the two critical components to separate, thus disconnecting the flight controls from the rudder actuators. The MP's properly-executed zero-to-negative-g input was the final—but not causal—condition that allowed the bolt to finally work free of the rod assembly. The pilot-induced pitch down, followed immediately by a non-pilot-induced rapid yaw and roll, incapacitated the MP, from which he never recovered.

I must note that not all of the rudder critical safety items were recovered from the mishap, and of those that were recovered, we were unable to definitively determine the location of the failure.

Nonetheless, the 30 degree rudder hardover can only occur due to a failure among these critical safety items.

I must also note that we cannot with absolute certainty rule out mechanical fatigue failure. However, there is no known T-38 mishap caused by a mechanical fatigue failure in the rudder operating mechanism, while two previous 30 degree hardover rudder failures were both absolutely proven to be the result of improperly secured fasteners on connecting rod “A”. Finally, my review of local maintenance practices gave me reasonable concern that the conditions for a maintenance failure to properly secure a bolt, and failure to detect it during proper inspection, did exist. These concerns are addressed below.

b. Contributing Factors

I researched various factors that could have substantially contributed to this mishap. There is no evidence to suggest the following were factors: medical, life style or crew rest issues; weather; life support, egress, or survival equipment; crew experience, qualification level, or currency; flight operations supervision; flight operations tempo; USAFTPS curriculum, academic instruction, or flight instruction; and mission preparation or briefing.

Given the high probability that the mishap occurred due to an improperly secured bolt in the rudder operating system, the AIB extensively reviewed available MA maintenance forms, including the aircraft AFTO 781 series forms, aircraft debrief forms, and products from the Integrated Maintenance Data System (IMDS). Additionally, we reviewed maintenance training procedures, processes and documentation. We interviewed 10 maintenance personnel, including two flight line and four phase aircraft mechanics, a phase dock work lead, an aircraft maintenance unit (AMU) chief, a Quality Assurance inspector, and the chief of the maintenance training division.

I find substantial evidence, based upon our review, to conclude that local maintenance training practices likely contributed to this mishap. Specifically, I determined the following factors to influence this determination:

(1) Training Requirements—General: Discrepancies between upper management and line mechanics in the “common understanding” of what training is required before a maintainer can work on an aircraft system. Thus, management insists (correctly) that maintainers must be signed off in their training records on each item, for each type of aircraft, in order to work on that aircraft. Line mechanics consistently stated (openly, sincerely, and incorrectly) they were hired as Aircraft Mechanics and thus could work any aircraft they were comfortable working on. (Human Factor: Local Training Issues/Programs)

(2) Training Requirements—Specific: Lack of knowledge of the specific requirements spelled out in the Civilian Master Training Plan (CMTP), which has been in effect since 2 August 2006. The AMU chief was unaware the T-38 Flight Control Rig was a special certification in the CMTP, and was also unaware that the CMTP was either official or approved (it is both). Thus, no mechanic in the 412 MXG was documented as

authorized to perform the T-38 Flight Control Rig. (Human Factor: Local Training Issues/Programs)

(3) Training Accomplishment—Documentation: We consistently saw training folders with little current documentation. A work lead told us “we don’t need training records signed to do maintenance.” One T-38 maintainer (WG-12) with 10 years experience had only 61% of his Job Qualification Standard tasks signed off; he worked on the rudder pedal rig, properly supervised, but was not signed off because there was no emphasis on doing so. He had received no documented training since getting canopy locking mechanism training in April 2008; prior to that, his last documented training was November 2007. Monthly reviews, required by the CMTP, are not documented on the Job Qualification Standard Record Review in each Individual Training Plan. (Human Factor: Local Training Issues/Programs)

(4) Training Discipline—General: Common reliance by work lead and shop-level supervision, as well as the individual maintainer, on an individual maintainer’s general credibility, reputation and “comfort” rather than determining if that individual is trained or qualified to perform a job. (Human Factor: Supervision—Discipline Enforcement)

(5) Aircraft Maintenance Actions—Documentation: The MA had received a 900-hour phase inspection in November 2008 – January 2009. In the computerized IMDS record, the maintainers signed off jobs and inspections by inserting names the IMDS would easily “accept” rather than taking the time and effort to ensure the name of the actual person who did the job or inspection was properly entered. Thus, the actual 781 aircraft forms and the IMDS do not agree. Because the 781 forms are destroyed after three months, there is no way to know who actually did the work or the inspections on the MA’s rudder system in the 900-hour phase. (Human Factor: Violation—Based on Risk Assessment)

(6) Aircraft Maintenance Actions—Quality Verification Inspection (QVI): The QVI was split into various partial inspections, accomplished at different times during the phase. This results in considerable work continuing in and around an area that has already been “signed off” as receiving its QVI. The final QVI occurs after the aircraft is completely put back together with all panels reinstalled. While this practice—the result of a “lean” event—allows for a quicker inspection process and can detect discrepancies early, a Quality Assurance inspector expressed concern that follow-on maintenance actions during phase could create new problems that would go undetected. (Human Factor: Cross-Monitoring Performance)

(7) Training Culture—General: Pervasive lack of concern—and thus lack of focus—on the need to understand what training is required, to systematically schedule and accomplish that training, to document the training, or to refer to the training folders in order to determine if an individual is qualified to work on an aircraft system. (Human Factor: Unit/Organizational Values/Culture)

These deficiencies in maintenance were identified as the board discovered that no witnesses and no records could identify the individuals who last worked on and inspected the MA rudder operating system. Hence, the board was unable to determine whether such individuals were qualified to work on the MA, or to question them about their work.

4. OPINION CONCLUSION

I find clear and convincing evidence that the cause of this mishap was a failure of the rudder operating mechanism, which disconnected the flight controls from the rudder actuators and caused the rudder to deflect 30 degrees left. This hardover rudder induced an uncontrollable yaw and a resulting roll, causing the aircraft to depart controlled flight. This condition is unrecoverable in the T-38.

Based on a review of physical evidence, expert testimony from T-38 mechanical systems engineers, and local maintenance practices, I find substantial evidence to conclude that it is highly likely that due to a maintenance error, one of the seven bolts securing the rudder operating mechanism "Critical Safety Items" was improperly secured. The unsecured bolt worked its way free over an unknown period of time, eventually backing out of its location sufficiently to allow the two critical components to separate, thus disconnecting the flight controls from the rudder actuators. The MP's properly-executed zero-to-negative-g input was the final—but not causal—condition that allowed the bolt to finally work free, disconnecting the rudder's controls. The pilot-induced pitch, followed immediately by a non-pilot-induced rapid yaw and roll, incapacitated the MP, from which he never recovered.

There are no indications of any materiel failure of a rudder operating mechanism component, in this case or in any previous T-38 mishap. There are several historical instances of proven failures to properly secure fasteners that led to hardover rudder failures—with no known instances of hardover rudder occurring any other way.

Finally, I find substantial evidence that convinces me that maintenance practices, indicated by a lack of focus on ensuring proper training, documentation, and oversight of maintenance personnel as they perform their duties, were a factor in allowing the conditions for an improperly secured bolt in the rudder operating system.

10 September 2009

CURTIS M. BEDKE, Major General, USAF
President, Accident Investigation Board

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