UNITED STATES AIR FORCE AIRCRAFT ACCIDENT INVESTIGATION BOARD REPORT

F-22A, T/N 91-4008

411TH FLIGHT TEST SQUADRON
412TH TEST WING
EDWARDS AIR FORCE BASE, CALIFORNIA

LOCATION: 6 MILES NORTH OF HARPER DRY LAKEBED, NEAR EDWARDS AFB, CALIFORNIA

DATE OF ACCIDENT: 25 MARCH 2009

BOARD PRESIDENT: MAJOR GENERAL DAVID W. EIDSAUNE

Conducted pursuant to AFI 51-503, Aerospace Accident Investigations

EXECUTIVE SUMMARY
AIRCRAFT ACCIDENT INVESTIGATION
F-22A, T/N 91-4008
EDWARDS AIR FORCE BASE, CALIFORNIA
25 MARCH 2009

On 25 Mar 2009, at 0927 local Pacific Standard Time, an F-22A aircraft, tail number 91-4008, assigned to the 411th Flight Test Squadron, 412th Test Wing, Edwards Air Force Base (AFB), California, departed Edwards AFB to conduct a weapons integration flight test mission. The mishap mission involved an F-22A mishap test aircraft (MTA) and an F-16D safety chase aircraft operating within restricted airspace 2508 located northeast of Edwards AFB. The MTA was instrumented to transmit flight telemetry data to a team of engineers who monitored MTA performance from the Ridley Mission Control Center.

The mishap test pilot (MTP) performed three similar high-speed, high-performance test maneuvers within specific parameters in order to evaluate how the weapons integration affects aircraft performance. The test parameters for all three maneuvers were Mach 1.60 +/- .02, target g-load, and altitude of 20,800 +/-2000 feet (ft) Mean Sea Level (MSL). To execute the tests, the MTP rolled the MTA inverted, performed half of a split-S maneuver, achieved the specific test point, and recovered by rolling the MTA right side up and pulling out of the dive. The first two test maneuvers were performed without incident. During the third maneuver, the MTA achieved the test point parameters at 22,800 ft MSL; however, the MTP continued a max g pull to an 83 degree nose low dive angle. When the MTA reached 14,880 ft MSL, the MTP made a full roll stick input to orient the MTA wings level and continued a full aft stick input to decrease the dive angle to approximately 50-degrees nose low. At 7,486 ft MSL, the MTP initiated ejection and immediately sustained fatal injuries. The MTA was destroyed upon ground impact, 35 miles northeast of Edwards AFB. There was minimal damage to private property and no civilian casualties.

This mishap was caused by the MTP's adverse physiological reaction to high acceleration forces and subsequent loss of situational awareness (SA) during recovery from the third test maneuver. The MTP channelized his attention to fight off the effects of high g-forces, characterized by grayout, light loss, and/or tunnel vision; meanwhile, the MTA entered an extreme nose down, high-speed attitude from which safe recovery was not possible. The MTP regained some SA but determined he was too low and descending too fast for a safe recovery. He ejected from the MTA outside the ejection seat design envelope and sustained fatal injury.

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

SUMMARY OF FACTS AND STATEMENT OF OPINION
F-22A, T/N 91-4008
25 MARCH 2009

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COMMONLY USED ACRONYMS & ABBREVIATION

ABW	Air Base Wing
ACC	Air Combat Command
ACE	Accelerated Cardiovascular Effect
ACES II	Advanced Concept Ejection Seat
ACM	Air Combat Maneuvering
ACS	Air Combat Simulator
ADI	Attitude Direction Indicator
AFB	Air Force Base
AFFTC	Air Force Flight Test Center
AFI	Air Force Instruction
AFMC	Air Force Materiel Command
AFOAP	Air Force Oil Analysis Program
AFPET	Air Force Petroleum Laboratory
AGL	Above Ground Level
AGSM	Anti G-Strain Maneuver
AHC	Advanced Handling Characteristics
ALOC	Almost G-Induced Loss of Consciousness
APU	Auxiliary Power Unit
ATAGS	Advanced Tactical Anti G Suit
ATP	Airline Transport Pilot
BATR	Bullets at Target Range
BFM	Basic Flight Maneuvers
CHP	California Highway Patrol
CM	Countermeasures
COMM	Communication
CPR	Cardio Pulmonary Resuscitation
CSMU	Crash Survivable Memory Unit
CTF	Combined Test Force
DNIF	Duty Not Including Flying
DO	Director of Operations
DoD	Department of Defense
DRS	Digital Recovery Sequence
DT	Developmental Test
DTC	Data Transfer Cartridges
DT&E	Development Test and Evaluation
EESS	Emergency Escape Sequencing System
EIR	Engineering Inspection Requirements
EKG	Electro Cardiogram
ELB	Emergency Locator Beacon
EMD	Engineering and Manufacturing Development
EOR	End of Runway
EP	Emergency Procedures
EVAL	Evaluation
FAA	Federal Aviation Administration
FCF	Functional Check Flight
FCIF	Flight Crew Information File
FL	Flight Level
FLCS IBIT	Flight Control System Integrated Built In Test
FLTS	Flight Test Squadron
FPM	Feet Per Minute
FRC	Fault Report Code
FTSO	Flight Test Service Orders
GAB	Ground Abort
GCAS	Ground Collision Avoidance System
GFR	Government Flight Representative
GLOC	G-induced Loss of Consciousness
GMP	General Minimizing Procedures
HELO	Helicopter
HUD	Heads up display
IADS	Interaction Analysis and Display System
ICAWS	Integrated Caution Advisory and Warning System
ICC	Installation Control Center
IMIS	Integrated Maintenance Information System
IPT	Integrated Product Team
IRCM	Infrared Countermeasures
JSF	Joint Strike Fighter
KCAS	Knots Calibrated Airspeed
KEAS	Knots Equivalent Airspeed
L	Local Time
LAX	Los Angeles Airport
LLE	Lead Loads Engineer
LSWB	Left Side Weapons Bay
MCC	Mission Control Center
MCP	Mishap Chase Pilot
MEC	Modulated Exhaust Cooling
MSL	Mean Sea Level
MTA	Mission Test Aircraft
MTP	Mission Test Pilot
MIC	Microphone
MSL	Mean Sea Level
NzW	Force Experienced in the Z-Axis
OAP	Oil Analysis Program
ODO	Operations Duty Officer
OG	Operations Group
Ops Tempo	Operations Tempo
ORM	Operational Risk Management
OSB	Option Select Button
OT	Operational Test
PCS	Permanent Change of Station
PHA	Physical Health Assessment
PHOTO	Photographer
QUAL	Qualification
Queep	Slang for paperwork
RAF	Royal Air Force
RCO	Range Control Officer
REGS	Regulation

RTB	Return to Base
SA	Situational Awareness
SAR	Search and Rescue
SDB	Small Diameter Bomb
SIM	Simulator
S/N	Serial Number
SOF	Supervisor of Flying
SWB	Side Weapons Bay
TC	Test Controller
TCTO	Time Compliance Technical Order
TD	Test Director
TDY	Temporary Duty
TEMS	Test & Evaluation Maneuver Simulator
THA	Test Hazard Analysis
TOD	Technical Order Data
TSP	Test Pilot School
TW	Training Wing
UCI	Unit Compliance Inspection
USAF	United States Air Force
VAL	Validation
VDC	Video Data Cartridge
VIS	Visibility
VMS	Vehicle Management System
VVH	Victor Valley Hospital
Z	Zulu or Greenwich Mean Time (GMT)

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

SUMMARY OF FACTS

1. AUTHORITY, PURPOSE, AND CIRCUMSTANCES

a) Authority

On 6 April 2009, Lieutenant General Terry L. Gabreski, Vice Commander of Air Force Materiel Command (AFMC) appointed Major General David W. Eidsaune to conduct an aircraft accident investigation of the 25 March 2009 mishap involving an F-22A aircraft, tail number (T/N) 91-4008, near Edwards Air Force Base (AFB), California (CA). The investigation was conducted at Edwards AFB, CA from 29 April 2009 through 29 May 2009. Accident Investigation Board (AIB) members included: Captain Christian Bergtholdt (pilot), Captain Alexandra Halchak (legal), Captain Nathan Kim (medical), Master Sergeant (MSgt) Richard Butturini (recorder), MSgt Patrick Lazarus (maintenance) and Technical Sergeant (TSgt) Shawn Bauer (court reporter) (Tab Y-3 thru Y-6).

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 Investigations 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 board was convened to investigate a Class A accident involving an F-22A aircraft, T/N 91-4008, assigned to the 411th Flight Test Squadron (411 FLTS), of the 412th Test Wing (412 TW), Edwards AFB, CA, which crashed on 25 March 2009.

2. ACCIDENT SUMMARY

On 25 March 2009 at 1710 Zulu (Z)/1010 Local (L) Edwards AFB Command Post was notified of an F-22 crash, call sign Raptor 07, tail number (T/N) 91-4008, assigned to the 411 FLTS, 412 TW, AFMC, Edwards AFB, CA (Tab B-3). The crash site was on private property 6 miles north of Harper Dry Lakebed and 35 miles northeast of Edwards AFB. The mishap test pilot (MTP), Mr. David P. Cooley, was fatally injured during ejection (Tab B-3). The mishap test aircraft (MTA) was totally destroyed at impact. The aircraft loss is valued at $140,000,000.00 (Tab P-3). The cost of MTA, equipment damage, and property restoration is valued at $154,997,607.06 (Tab P-3). The main impact site was contained to approximately a 45 Feet (ft) x 48 ft x 20 ft deep crater. The property damage to the mishap site consisted of ground scarring and chemical (fuel, hydraulic fluid) contamination (Tab P-4).

3. BACKGROUND

Air Force Material Command (AFMC), Wright-Patterson AFB, Ohio

AFMC is an Air Force Major Command (MAJCOM) 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 readiness.

Air Force Flight Test Center (AFFTC), Edwards AFB, California

The Flight Test Center has played a critical role in the development of the country's aircraft, from the 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.

95th Air Base Wing (95 ABW), Edwards AFB, California

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 1500 Air Base Wing members support the AFFTC and the 412 Test Wing (412 TW) mission.

412th Test Wing (412 TW), Edwards AFB, California

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.

411th Flight Test Squadron (411 FLTS), Edwards AFB, California
The 411 FLTS is an operational F-22 Combined Test Force (CTF). A CTF is an organization that includes developmental test and evaluation personnel from the military, government civilians and prime/support contractors. Collectively, CTF personnel formulate the test program, develop and execute flight test missions, analyze data from test flights and report on the results. This dynamic organization enables a less costly, more efficient and effective test program to produce a superior aerospace system.

4. SEQUENCE OF EVENTS

a) Mission

The mishap mission was a weapons integration test flight involving an F-22A test aircraft, call sign Raptor 07 and an F-16D safety chase aircraft, call sign Eddy 01 (Tabs C-3, DD-4). The mishap test mission was measuring load forces, flutter and vibroacoustics for the weapons integration on the test aircraft under specific in-flight conditions. The F-22A test aircraft was equipped to transmit real time voice communications and telemetry to the Mission Control Center (MCC), where engineers monitored the in-flight conditions of the F-22 and ensured data was captured on pre-determined test points. To facilitate testing, the cockpit of the test aircraft is specially wired for open and constant communication with MCC personnel, to include the Test Conductor (TC), Test Director (TD) and several discipline specific engineers (Tabs N-3 thru N-16, DD-4). During the weapons integration tests, Eddy 01, due to F-16D configuration and speed/acceleration limitations, flew as an area chase at ranges up to 12 miles behind the test aircraft. For this mission the area chase's responsibilities were minimal; the area chase was merely present to provide "Wet-Dry Checks" prior to the start of testing. Eddy 01 was piloted by the mishap chase pilot (MCP) and carried a passenger, who videotaped segments of the test mission (Tab V-2.4, V-4.4, V-5.2). The F-22A mishap test aircraft (MTA) was assigned to the 411 Flight Test Squadron (FLTS), 412 Test Wing, Edwards AFB, CA (Tab C-4) and the F-16D was assigned to the 445 FLTS (Tab K-4). The mission took place in restricted area 2508 airspace (R2508) located northeast of Edwards AFB, CA. R2508 is designated a military operating restricted area over the Mojave Desert, which is characterized by rolling desert terrain (Tab K-4, K-5).

The MTA and Eddy 01 departed Edwards AFB at 1627Z/0927L and proceeded to R2508 (Tab N-10). In accordance with AFI 11-2FT, Volume 3, *Flight Test Operations Procedures*, the MTP, executed two 90-degree g-warm-up turns in preparation for the high-g test maneuvers that he would be executing (Tab DD-5). The initial g-warm-up turn is to ensure that the aircraft and g-suit are operating correctly and the secondary higher g-turn is to ensure that the pilot is prepared for the physical requirements of the high-g environment.

The MTP also performed several routine maneuvers to calibrate the MTA's instrumentation (Tab V-11.6). During these maneuvers, the videographer in Eddy 01 captured video footage of the

MTA's left Side Weapons Bay (SWB) and Infrared Countermeasures (IRCM) doors opening and closing (Tab V-2.2).

At approximately 1641Z/0941L, the MTP set up for the first of two test maneuvers at specific airspeeds, altitudes, and a range of g-loads with the left SWB door open and the missile launcher extended. The third test maneuver would be identical to the first two maneuvers, but would be executed at a different g-loading and the SWB door would be opened while under g (Tab DD-128). The desired test parameters or test band for all three test maneuvers were 1.60 Mach plus or minus .02 Mach, altitude of 20,800 ft MSL plus or minus 2,000 ft, and a designated target g-loading (Tabs N-12, AA-17, AA-18, DD-137). The MTP initiated the three test maneuvers at an altitude of 25,000 ft above Mean Sea Level (MSL) and an airspeed of 1.65 Mach (Tabs V-1.3, AA-17, AA-18). For each test the MTP executed half of a split-S maneuver, which involves rolling the aircraft to an inverted position and then flying half of a loop. During the first half of the split-S maneuver, telemetry was collected from various sensors on the MTA. The MTP was then to recover from a nose low position by putting throttles in idle and simultaneously rolling the MTA right side up while pulling the nose up to a level/climbing attitude (Tabs V-1.3, AA-17, AA-18, DD-137). Executing the maneuver in this manner reduces the amount of altitude lost (Tab DD-137). F-22 simulator testing demonstrates a pilot must recover using this technique as a full split-S maneuver leads to ground impact.

MCC engineers monitor and record the MTA's flight conditions and systems via telemetry to include: electrical, hydraulic, engine, and other aircraft system data; as well as aircraft airspeed, pressure altitude, g-loading, and angle of attack data (Tab DD-4, DD-5). During the test maneuvers, the engineers provide the MTP feedback to confirm collectible data was captured during the execution of the test.

After the first two test maneuvers, the MTP proceeded to air refuel at the tanker. After refueling, he set-up for the third test while Eddy 01 air refueled. The third test was expected to be nearly identical to the second test, except for a slightly lower amount of g-loading and the SWB doors would be opened while under g-loading (Tab N-13, N-14).

The MTP was a retired USAF pilot, age 49, employed by Lockheed Martin as a test pilot at the time of the mishap. He was a current and qualified Functional Check Flight (FCF) pilot who was also qualified to conduct loads flight tests, like those conducted on the day of the mishap (Tab G-5, G-66). The flight was properly authorized in accordance with Air Force Instruction 11-401, *Aviation Management* by the 411 FLTS Assistant Director of Operations, on behalf of the 411 FLTS Commander (Tab AA-3, AA-4).

b) Planning

In preparation for this test mission, the MTP attended the F-22 Test and Evaluation Maneuver Simulator (TEMS) in accordance with the *F-22A Risk Reduction Captive Carriage Test* Safety Plan to practice the flow of the tests and determine appropriate starting parameters to achieve the test points. The TC and the Lead Loads Engineer (LLE) accompanied the MTP to the TEMS practice and took notes regarding the starting parameters, test conditions, and lessons learned (Tabs AA-13, AA-14, V-1.2, V-5.3). During simulator practice, the MTP was coughing and commented he had a cold (Tab V-1.3, V-1.5, V-12.2). The MTP practiced the mishap maneuvers at a temperature setting of +15 degrees Celsius above standard day (Tab AA-13). The temperatures at altitude on the day of the mishap were +5 degrees Celsius above standard day, which means that the MTA would perform better than it had in the TEMS (Tab F-6). Specifically, the MTA would produce more thrust, turn tighter, and lose less altitude.

Two other test pilots from the 411 FLTS executed these tests in the TEMS individually on 17 and 19 March and determined the ideal starting points for these tests were 25,000 ft MSL and 1.65 Mach. Simulator practice notes were incorporated into the test cards created by the TC (Tab AA-13, AA-14). These starting parameters facilitate the achievement of the desired test parameters of 20,800 ft MSL, plus or minus 2,000 ft and 1.60 Mach, plus or minus .02 (Tab V-1.3). A significant amount of practice, concentration and skill are required to fly these test profiles due to the specific parameters that must be achieved, as well as the high speeds and high g-levels that the MTA and MTP would experience (Tab V-11.3, V-11.10). The test team was well prepared and very familiar with the physical and mental demands of the tests (Tab V-12.3, V-14.3). The MTP had previous captive carriage test experience and flew a test mission on 23 March, two days prior to the mishap mission (Tab AA-7).

At approximately 1345Z/0645L on 25 March 2009, the MTP briefed the mishap test mission per requirements set forth in Joint Procedure 221, Flight Test Mission Brief and Debrief. The TC, TD, MCP, Range Control Officer (RCO), LLE, utilities & subsystems engineers, propulsion engineer, and a weapons integration expert were present for the mishap mission brief (Tab V-1.2, V-4.2, V-4.5). The MTP discussed the various test profiles, how he would fly them, as well as safety mitigation procedures outlined in the *F-22A Risk Reduction Captive Carriage Test* Safety Plan (Tabs AA-15 thru AA-17, V-1.3, V-5.3). The test profiles were designed by the TC and were printed on cards labeled with a letter and a number (Tabs AA-13, AA-14, V-1.6). These cards were distributed and discussed at the mission briefing. The TC took care to highlight the fact the tests would be conducted at very high airspeeds and heavy g-loadings--it was deemed a medium risk test mission (Tabs V-1.6, AA-5). The TC also highlighted that anyone in the MCC or the MTP could call a Knock-it-Off if an unusual or dangerous situation developed (Tab V-1.4, V-4.3, V-12.5, V-14.5).

After the mission briefing, the MTP met with the MCP and videographer to discuss their specific duties during the test mission. The MCP was to perform periodic “Wet-Dry Checks” of the MTA to ensure secure panels and no leaking fluids. Additionally, the MTP briefed that Eddy 01 should remain 7 to 12 nautical miles from the MTA during the test maneuvers (Tab V-2.3).

The mission brief was efficient, professional and thorough (Tab V-4.4, V-5.6, V-14.2). All parties present were comfortable and pleased with the level of planning and preparation for the test mission (Tabs V-1.5, V-4.4, V-5.6, V-14.3).

c) Preflight

The MTP stepped to the 411 FLTS operations desk and received a final update briefing on the weather, Notices to Airmen (NOTAMs), current airfield conditions, and other safety-of-flight information prior to proceeding to the MTA (Tabs AA-3, V-15.2). Prior to being cleared to fly, pilots are required to fill out Operational Risk Management (ORM) paperwork to identify risk factors such as: lack of adequate rest, early arrival times, adverse weather that may be encountered, etc. The MTP's ORM assessment for this sortie was categorized "yellow" indicating a medium level of risk. The ORM sheet reported "yellow" because the MTP had five to eight hours of sleep the night prior, arrived early for the 0645 mission brief, the mission complexity was demanding, the test mission safety risk was medium, and the MTA was carrying modified hardware/software (Tab AA-5). The MTP had the opportunity, but declined to identify personal concerns, such as sickness (Tab AA-5).

The MTP stepped to the jet slightly after the briefed step time because the MTA was not pilot ready (Tab V-9.3). At 1538Z/0838L the MTP performed standard aircraft checks and instrument calibration tests with the Crew Chief at the MTA and the engineers in the MCC. During aircraft checks, the MTP coughed and mentioned he was recovering from a cold; when queried he confirmed he was okay to fly (Tab V-1.5, V-9.2, V-13.2). The MTP dealt with several minor, non-safety-of-flight aircraft issues while on the ground and was subsequently cleared for takeoff by engineers in the MCC (Tab N-3 thru N-10). The MTP waited at the end of the runway approximately 15 minutes for Eddy 01, which delayed the scheduled 1600Z/0900L takeoff time (Tab N-8 thru N-10).

d) Summary of Accident

The MTA and Eddy 01 took off at 1627Z/0927L, 27 minutes after scheduled takeoff time and proceeded to R2508 (Tab N-10). The departure, wet-dry check, g-warm-up turns, instrument calibration, and door opening and closing tests were uneventful and executed per the brief (Tab N-10, N-11).

Upon completion of the calibration exercises and g-warm-up turns, the MTP set up for the briefed test maneuvers. The three test maneuvers were nearly identical, except for the target g-loads and when the SWB door would be opened (Tab N-12). Before each test maneuver, engineers in the MCC calculated a desired target g-loading based on aircraft weight derived from the MTA fuel level (Tab N-12).

At 1641:09Z/0941:09L the MTP set up the first test maneuver by opening the left SWB door and rolling the MTA inverted while accelerating to 1.65 Mach (Tab N-12). The MTP pulled straight down from 25,000 ft MSL and achieved the required test parameters within seconds (Tab N-12). The TC announced "point complete," and the MTP recovered the MTA (Tab N-12). "Point complete" is called by the TC as an indication to the pilot that he has passed through the desired test band on parameters and that no further maneuvering is required. All test pilots interviewed indicate this call is informative, not directive, and they begin recovering the aircraft as soon as they recognize they have passed through the desired test band (Tab V-6.4, V-6.5, V-8.6, V-10.4). During MTA recovery on the first test maneuver, the MTP experienced high g-loading (Tab V-12.4). The MTP was under g-load for a total of 15 seconds, from the time the test was initiated at 1641:09Z/0941:09 until recovery was completed at 1641:24Z/0941:24.

During the first test maneuver, the left IRCM doors opened inadvertently (Tab N-12). The IRCM doors are located aft of the SWB doors along the same fuselage line. The MTP thought his pencil might have hit a button, accidentally opening the left IRCM doors (Tab N-12). The MTP indicated he would move his pencil so this would not occur again (Tab N-12). It is unknown if this was an aircraft anomaly or if the MTP's pencil could have actually hit the door open button. The unintended opening of the IRCM door did not invalidate test data nor did it cause any undue stress to the aircraft or the IRCM door (Tab V-12.9).

Prior to the second test maneuver, the MCC calculated a g-load requirement that was higher than the previous test and communicated this to the MTP (Tab N-13). In fact, the second test maneuver required the highest target g-load of the three test maneuvers comprising the mishap mission. At 1644:34Z/0944:34L, the MTP rolled the MTA inverted, paused briefly (to let the nose drop to five degrees nose low to ensure a starting airspeed of 1.65 Mach) and then pulled to achieve the desired g-load while descending through the altitude band (Tab DD-140). Within 7.8 seconds of rolling inverted the MTP completed the test. At 1644:41Z/0944:41L, the TC called "point complete" (Tab N-13). The MTP immediately executed the recovery procedure from 51 degrees nose low at 22,400 ft MSL, 1.6 Mach, high g-loading, with a significant descent rate (Tab DD-140). To recover the MTA, the MTP made a full lateral stick input, while maintaining full back stick pressure. The lateral input rolled the MTA to a right-side-up position while the constant back stick pressure kept the MTP under high g-forces, which reduced the altitude lost during recovery. Within .04 seconds of initiating the roll to right-side-up, the MTP brought the throttles to idle. At this point, the MTA was at 22,030 ft MSL, 55 degrees nose low, 1.6 Mach, same high g-loading, and at an even faster descent rate (Tab DD-140). During recovery, the MTA's lowest altitude was 13,600 ft MSL. The MTP was under high g-loading from 1644:35Z/0944:35L until 1644:50Z/0944:50L, for a total of 15 seconds and reached high-g (Tab DD-140). While under g-loading, the MTP executed an anti-g straining maneuver (AGSM), which is a breathing and muscle straining technique used to counteract heavy g-forces. The breathing aspect of the MTP's g-strain was labored and strained (Tab V-1.5, V-4.3, V-12.7). Seconds after the MTP let off g from this test he said, "Oh man" (Tab N-13). Members of the MCC either did not hear the MTP's comment, or felt that it did not warrant attention (Tab V-12.10).

Prior to the third test maneuver, the MTP air refueled with the tanker aircraft. While flying to the tanker, the MTP and the MCC both noted the left IRCM door had opened inadvertently again during the test. The MTP was concerned and thought he might have unintentionally opened the door (Tab N-14, N-15). The planned air refueling increased the MTA's gross weight, thereby slightly reducing the g-available for the third test maneuver (Tab V-1.4). Increasing the MTA's gross weight made it easier for the MTP to achieve the required test parameters without exceeding the MTA's loads limits (Tab V-1.4). While the MTP was refueling, the MCA rejoined to the wing of the tanker. The MTP refueled uneventfully and departed (Tab N-14). The MTP set up for the third test profile, but waited until the MCA departed the tanker before starting the third test maneuver (Tab N-15).

At 1659Z/0959L, the MTP set up for card 18, test point 3 (Tab N-15). For the third test maneuver, the MCC recalculated a slightly higher target g-load (but lower than the previous test maneuver's target g-load) based on actual MTA fuel weight (Tab N-16). Additionally, for this test, the MTP was required to open the left SWB door no earlier than 22,800 ft MSL while the MTA was in the test band under g, whereas previous tests only required the door to be open prior to starting the test (Tab N-16).

At 1701:50Z/1001:50L, the MTP rolled inverted and began the third test maneuver (Tab N-16). The MTP opened the left SWB door 1,360 ft early, at 24,160 ft MSL (Tab DD-138). This discrepancy did not necessarily invalidate the test data, as the MTA had achieved the required g-loading when the door was opened. The MTP continued to pull as the MTA descended through the test band and the nose of the aircraft progressed to a steeper dive angle. A "Point Complete" call, which had been made in the two previous tests, was not made by the TC (Tab N-16).

The left IRCM door did not open during this test maneuver as it had during the first two tests (Tab DD-117 thru DD-121).

The MTP executed a labored and strained AGSM (Tabs V-1.5, X-3). Nine seconds after initiating the maneuver, the MTP pulled the throttles to idle power, indicating that he was no longer conducting the test maneuver. The MTA was at 19,890 ft MSL, 1.56 Mach, 65 degrees nose low, just below target g-load, and at a very fast decent rate (Tab DD-138). The MTA was 2,140 ft lower with a pitch attitude 10 degrees steeper than on the previous test when the MTP pulled the throttles to idle (Tab DD-140). The recovery procedure required the MTP to simultaneously pull the throttles to idle while rolling the aircraft to an upright attitude. After descending another 1,220 ft to 18,770 ft MSL, the MTP made a slight lateral stick input to roll the MTA upright (Tab DD-138). This lateral input did little to change the MTA from an inverted position to an upright recovery position and, because the MTP had not rolled the MTA upright, its dive angle steepened to 72 degrees nose low (Tab DD-138). The MTA was much lower and at a much steeper descent angle than in the previous two test maneuvers. Three seconds elapsed from when the MTA was within the test band to this extremely nose low position. At 14,880 ft MSL, 83 degrees nose low, and Mach 1.49 the MTP made a full lateral input to roll the MTA right-side-up (Tab DD-138). Because the MTA was pointed nearly straight down at a very high airspeed and descent rate, the MTA was losing altitude at an extreme rate. The MTP continued to perform a very labored AGSM (Tabs V-1.4, V-4.3, V-12.7, X-3).

After the MTP made a full lateral input to roll the MTA upright, it continued to descend at a very high rate. At this point, the MTA was at 7,486 ft MSL, right side up at 53 degrees nose low, Mach 1.36, 793 KCAS, high g, and at a rapid descent rate (Tab DD-138). Approximately 17 seconds into the third test maneuver, the MTP released the controls and initiated ejection approximately 3,900 ft above ground level (AGL), 765 KEAS and Mach 1.3 (Tab H-3, H-6).

The MTP suffered fatal injuries during the ejection sequence due to blunt force trauma caused by wind blast (Tab X-9). The MTA impacted the ground approximately 1.49 seconds after the MTP ejected. An aircraft in the vicinity of the MTA impact site notified the local SPORT air traffic controller of situation. SPORT directed Eddy 01 to investigate and the MCP assumed responsibility as the on-scene search and rescue commander (Tab V-5.6).

e) Impact

The MTA impacted the ground at approximately 1702:10Z/1002:10L on 25 March 2009 at latitude 35 07 North and longitude 117 27 West at an elevation of 2,400 ft MSL (Tab H-6). According to aircraft telemetry data, ejection was initiated when the MTA was at 6,340 ft MSL, 765 KEAS, 45 degrees nose low, with wings approximately level (Tab P-4). After the MTP initiated ejection, the MTA rolled right, pitched down and impacted the ground approximately 1.49 seconds later (Tabs P-4, H-6). The impact area is privately owned and consists of barren desert with low shrubs. The aircraft created a 45 ft x 48 ft x 20 ft crater and scattered debris across an area extending 2,800 ft from the impact point (Tab P-4). Due to the MTA's speed at impact, few parts and components were recognizable.

f) Life Support Equipment, Egress and Survival

The MTP ejected at 6,340 ft MSL, approximately 3,900 ft AGL, under significant g-force and at 765 KEAS and Mach 1.3 (Tab H-3, H-6). The MTP's ejection occurred outside the modified Advanced Concept Ejection Seat II (ACES II) performance envelope, in excess of the airspeed design limit (Tabs H-3, DD-27). The modified ACES II is designed for a maximum ejection airspeed of 600 KCAS, which means the MTP's ejection was initiated approximately 150 knots above design limits (Tab DD-27 thru DD-37). According to Technical Order 1F-22A (EMDAV)-1 *F-22A Flight Manual*, based on the MTP's bodyweight, ejections above 550 knots yield a greater than 80 percent chance of a major/fatal injury rate predominately due to wind blast encountered during ejection.

Post-mishap analysis indicates the Emergency Escape Sequencing System (EESS), aircraft canopy, modified ACES II, and other ejection components operated as designed, but sustained some damage due to high speed ejection (Tab H-3 thru H-18). The modified ACES II was subjected to significant accelerations and decelerations during the ejection sequence. According to the Digital Recovery Sequencer (DRS) accelerometer, the seat approached +60/-35 g's in the vertical axis at a rate significantly higher than observed in ejection seat sled testing (Tab H-3, H-14). The modified ACES II headrest, seat back, rollers, and seat pan side caps sustained structural damage from substantial loading due to high wind blast (Tabs H-3, H-8 thru H-10, DD-33 thru DD-37). Analysis confirms the arm restraints deployed during ejection, but ineffectively prevented arm flail in the high speed environment. The leg restraints were retracted and cinched as designed, but wind blast damaged the bungees and caused them to fail (Tabs H-3, H-10, H-11, DD-35, DD-45, DD-46).

Analysis of the MTP's damaged helmet suggests his head struck the headrest pad of the seat during ejection. The initial windblast during ejection into the wind stream caused further helmet damage (Tab DD-47, DD-51, DD-52, DD-73).

The MTP's anti-g garments, to include the Advanced Tactical Anti-G Suit (ATAGS) and the Combat Edge anti-g vest were properly inspected by Aircrew Flight Equipment personnel prior to the mishap mission (Tab AA-7 thru AA-12). Post-mishap operability tests confirm each item functioned as designed during the mishap test mission (Tab AA-7).

The MTP's parachute deployed during ejection. Analysis confirmed minor tearing on several panels of the parachute, which is consistent with damage observed during high speed ejection testing (Tab H-3). The minor tearing did not compromise the MTP's ability to execute a safe parachute landing. The survival kit deployed after MTP-seat separation, which indicates the MTP was under parachute for a minimum of four seconds (Tab H-3). The LRU-16/P life raft was found fully inflated and appears to have functioned automatically, as designed (Tab Z-3).

All egress system and aircrew flight equipment inspections were current and all survival equipment functioned as designed, despite an ejection that occurred outside of the designed airspeed envelope (Tabs DD-27 thru DD-37, U-57 thru U-61).

The Emergency Locator Beacon (ELB) attached to the survival kit was found in the manual mode, which would require the MTP to activate it post-ejection (Tab DD-79). It is standard practice during training missions to set the ELB to the automatic mode; where post-ejection it would activate and transmit a signal that can be heard by nearby aircraft and search and rescue personnel. The ELB had no bearing on the outcome of the mishap.

g) Search and Rescue (SAR)

At 1702Z/1002L, the MCC reported loss of the MTA's telemetry data. Also, SPORT lost radio contact, radar contact and the IFF (Identification, Friend or Foe) beacon code identified as Raptor 07. At 1703Z/1003L, the MCP attempted to contact the MTP without success (Tab V-5.7). An aircraft in the vicinity of the impact site reported a fireball and smoke. At approximately the same time, the MCP reported smoke on the ground and proceeded towards it to investigate (Tab V-5.6). The SPORT controller advised his supervisor of the possibility of a downed aircraft. At 1707Z/1007L, the MCP directed the SPORT controller to mark his scope over a large crater surrounded by multiple small fires (Tab V-5.6). The MCP assumed responsibility as the On-Scene Commander and descended to 5500 ft MSL and orbited above the crater while looking for the MTP's parachute (Tab V-5.6).

After verifying an aircraft mishap had occurred, SPORT contacted the Edwards AFB Control Tower (Edwards Tower). Edwards Tower then initiated their aircraft accident checklists and placed a call on the crash phone and notified several agencies, including Edwards AFB Base Operations. Base Operations in turn activated the secondary crash net and notified the Edwards AFB Command Post. At 1710Z/1010L, Edwards AFB Command Post was notified the MTA impacted the desert (Tab B-3).

The Supervisor of Flying (SOF) at Edwards Tower began coordinating search and rescue (SAR) assets as soon as he was notified of a downed aircraft. The SOF contacted Naval Air Station China Lake and the Marine Aircraft Group 46, Detachment B for helicopter support. The SOF was unable to reach Marine Aircraft Group 46 and contacted U.S. Army SAR assets at Fort Irwin, CA. Both Navy and Army assets responded to the mishap (Tab V-18.4, V-20.1, V-21.1 thru V-21.3).

In addition to the SOF requesting SAR forces, calls were made to the California Highway Patrol (CHP) and to the San Bernadino Police Department (Tab V-20.1). At approximately 1730Z/1030L a CHP Cessna aircraft responded to notification of a possible downed aircraft in the vicinity of Red Mountain (Tab V-20.1). The SPORT controller cleared the CHP aircraft into the restricted airspace and it orbited at 5,500 ft MSL. Eddy 01 authorized the CHP aircraft to descend to 200 ft AGL. The CHP aircraft quickly located the MTP, who was still attached to his parachute, life raft, and survival kit (Tab V-5.7). Approximately 20 minutes later, the CHP aircraft departed to allow inbound rescue helicopters access to the MTP (Tab V-20.1).

At approximately 1715Z/1015L, a Navy CH-60 helicopter pilot was notified of the MTA crash. He recalled his crew, provided a SAR brief and departed at 1756Z/1056L with call sign Rescue 46. At 1812Z/1112L, 16 minutes after departure, Rescue 46 arrived at the MTP's location and deployed medical/rescue personnel. The MTP was unresponsive, positioned flat on his back, without his helmet and found attached to his parachute. Medical personnel initiated cardiopulmonary resuscitation and administered medical care (Tab V-21.1 thru V-21.3).

At 1700Z/1000L, an Army Medical Evacuation UH-72 Lakota helicopter (Army UH-72) departed from Fort Irwin on a local training mission. At approximately 1735Z/1035L, the Army UH-72 was directed to assist in the MTA rescue operation. Within 13 minutes the Army UH-72 re-fueled and departed for the crash site at 1755Z/1055L. At 1824Z/1124L, the UH-72 landed near the MTP and deployed additional medical personnel to assist the Navy medics. The MTP was secured to a litter and loaded into the Army UH-72 at 1831Z/1131L (Tab V-25.1). The UH-72 was initially directed to transport the MTP to Antelope Valley Hospital, but was subsequently re-directed to a closer facility, Victor Valley Hospital (VVH) (Tab V-21.1 thru V-21.3). At 1854Z/1154, the Army UH-72 landed and was met by a VVH trauma team (Tab V-22.1).

h) Recovery of Mishap Test Pilot

At 1832Z/1132L, the MTP was transported via helicopter to the VVH Emergency Room. The MTP was declared deceased and recovery efforts terminated at 1903Z/1203L (Tabs B-2, V-25.1). An autopsy was conducted by the San Bernardino County Coroner's Office on 26 March 2009.

5. MAINTENANCE

a) Forms Documentation

F-22 aircraft maintenance is managed via an electronic management database referred to as the Integrated Maintenance Information System (IMIS). IMIS tracks scheduled and unscheduled maintenance activities, scheduled and unscheduled engine maintenance activities, repairs, aircraft flying hours, maintenance personnel activity, and Technical Order Data (TOD). Engineering Inspection Requirements (EIR) and Flight Test Service Orders (FTSO) were initiated to request and document MTA maintenance, testing, modifications and inspection activities. A thorough review of the MTA's IMIS, EIR, and FTSO records from 1 January 2009 through 24 March 2009 reveal the MTA had no recurring maintenance problems that contributed to the mishap (Tab DD-10).

IMIS is the computer based server which extracts information pertaining to aircraft maintenance from the F-22 Data Transfer Cartridges (DTC). The DTC is a multi-function component capable of tracking the health of the aircraft during flight. In-flight maintenance discrepancies are captured on the DTC and downloaded to IMIS post-flight. Additionally, maintenance personnel enter discrepancies manually and record corrective actions in IMIS. The MTA's IMIS historical maintenance records from 1 January 2009 through 24 March 2009 were reviewed post-mishap. There is no evidence any maintenance discrepancy or maintenance corrective action contributed to the mishap (Tab DD-7).

EIRs are developed by a group of system engineers called an Integrated Product Team (IPT). Each IPT develops specific EIRs based on data collected from previous missions to determine aircraft inspection, modification, and upgrade requirements. EIRs are then issued to maintenance personnel to accomplish inspections, modifications, or upgrades on a specific area of the flight test aircraft.

FTSOs are generated by system engineers to identify routine scheduled and unscheduled aircraft actions. FTSOs are paper records and may also incorporate EIRs.

There are no Time Compliance Technical Orders (TCTOs) listed for the MTA because TCTOs do not apply to flight test aircraft. TCTOs serve to identify routine, safety, or emergency conditions that require inspections, modifications, or upgrades to a specific system on a particular aircraft. Inspections, modifications, and upgrades for flight test aircraft are identified and accomplished through EIR (Tab U-19 thru U-36).

b) Inspections

Phased inspection requirements do not apply to flight test aircraft because all major and minor phased type inspections are accomplished through EIRs. All EIRs for the MTA were current and the EIR forecast report shows no overdue EIRs (Tab U-19 thru U-36). The MTA's last EIR called for the monthly hook force inspection; it was accomplished on 23 March 2009 (Tabs D-3, U-19).

c) Engines

Both MTA engines are Pratt &Whitney F119-PW-100A. The engines are numbered 1 and 2 from left to right as if you were positioned in the aircraft. The MTA's number 1 engine had 1288.39 total engine operating hours and 40.79 total flight time hours while installed in the MTA. Engine 1's last major overhaul was 10 January 2009 (Tab D-3). The MTA's number 2 engine had 992.38 total engine operating hours and 42.33 total flight time hours while installed in the MTA (Tab D-3). Engine 2 had not reached enough total engine operating time to meet requirements for the first major overhaul. All engine 2 inspections were accomplished prior to installation in the MTA on 13 January 2009 (Tab U-37 thru U-41). No significant engine maintenance, scheduled or unscheduled, was relevant to the mishap.

d) Maintenance Procedure

All pertinent records, maintenance procedures, practices, and actions were reviewed and did not contribute to the mishap event.

e) Maintenance Personnel and Supervision

A thorough review of relevant Air Force maintenance members AF Form 623's, *Individual Training Record*, and AF Form 797's, *Job Qualification Standard*, as well as civilian contract employee training records occurred post-mishap. All maintenance personnel who worked on the MTA had adequate training, experience and expertise to complete assigned tasks.

f) Fuel, Hydraulic and Oil Inspection Analysis

Fuel, hydraulic, and oil samples were taken from equipment used to fuel and service the MTA. Samples were not collected from the mishap site. The Air Force Petroleum Laboratory (AFPET) located at Wright-Patterson AFB, Ohio performed contamination tests on all MTA equipment samples. Test results were within acceptable limits (Tab U-43 thru U-56).

In accordance with the Oil Analysis Program (OAP) at Edwards AFB, CA, an all wear-metal oil analysis was conducted on each MTA engine prior to the mishap. Air Force OAP uses atomic emission spectroscopy to determine equipment wear. Oil samples are taken from each engine after every flight to check for signs of component failures and signs of engine bearing wear within the oil system. The MTA's oil sample results were within acceptable limits (Tab D-3).

g) Unscheduled Maintenance

The MTA flew 15 missions between 1 January 2009 and 23 March 2009 (Tab D-9 thru D-10). The MTA returned without major discrepancy on 11 of the 15 missions. The remaining four missions had major discrepancies mandating corrective action on the MTA prior to flying again. The major discrepancies involved: weapons doors and IRCM doors opening unexpectedly in flight, IRCM door failure, right horizontal stabilator (stab) actuator leaking, and blockage of the pilot suit heat exchanger. All discrepancies were corrected prior to the mishap mission (Tab D-9 thru D-10).

The MTA also had two ground aborts (GAB) during the same time period. A GAB occurs when a scheduled mission is canceled due to any aircraft discrepancy that could potentially affect the mission. The first of two GABs resulted from three consecutive Flight Control System Integrated Built-In Test (FLCS IBIT) failures (Tabs D-10, U-11). These FLCS IBIT failures were caused by a faulty right horizontal stab actuator. The right horizontal stab actuator was removed, replaced and the operational check was positive (Tabs D-10, U-3 thru U-4). The second GAB involved the failure of the modulated exhaust cooling (MEC) actuator on engine 2 (Tabs D-9, R-3). The engine diagnostic information was downloaded and indicated the MEC actuator was stuck in the open position. The MEC actuator was removed, replaced and the operational check was positive (Tab R-3).

6. AIRCRAFT AND AIRFRAME SYSTEMS

The MTA's high rate of speed at impact destroyed all components of the aircraft. Minimal MTA wreckage was recovered at the mishap site except for the canopy, ejection seat, and many unrecognizable parts (Tab S-4 thru S-6).

Lockheed Martin Aeronautics Company conducted an assessment and analysis of the MTA's telemetry data from the Interactive Analysis and Display Systems (IADS). IADS is an analysis and display software tool specifically developed for flight test aircraft, which addresses data delivery, visualization and analysis. IADs data analysis confirms the MTA's Flight Control, Environmental Control, Fuel, Hydraulic Power, and Electrical systems were all operating properly at the time of the mishap (Tab DD-3 thru DD-10).

The MTA's structural integrity, specifically the left IRCM door hydraulic pressures, left IRCM door position angle, and weapon bay door position angles were evaluated based on IADS data post-mishap. Analysis confirms the IRCM and weapon bay doors operated correctly during the mishap test maneuver (Tab DD-121). There is no indication a structural problem or failure occurred on the MTA (Tab DD-151).

Analysis of the crash survivable memory unit (CSMU) validated parameters recorded from the MTA's IADS data and did not provide any additional information (Tab DD-21).

7. WEATHER

a) Mission Weather Forecast

On 25 March 2009 the weather forecast for R2508 predicted scattered to broken clouds at Flight Level (FL) 250 (25,000 ft MSL), unrestricted visibility, and variable surface winds at 6 knots with an altimeter of 29.96 inches mercury (Tab F-3). The term "scattered" means clouds cover less than 50% of the sky, and "broken" refers to cloud layers that cover more than 50% of the sky. Light to moderate turbulence was forecast between FL 180 – 400 and winds were briefed to be from the northwest increasing with altitude up to 35 knots at FL 300 (Tab F-3 thru F-5).

b) Observed Weather

Eddy 01 reported clear sky conditions and light winds in R2508 (Tab F-6). The observed altimeter was 30.10 inches mercury at 1555Z/0855L (Tab F-6). Measured temperature at 20,000 ft MSL was -20 degrees Celsius.

c) Conclusion

Weather did not contribute to this mishap.

8. CREW QUALIFICATIONS

a) Training

The MTP was a current and qualified FCF pilot and loads test pilot for the mishap test mission (Tab G-12, G-14, G-66). He accomplished F-22 transition academic and simulator training at Tyndall AFB, Florida from August 2007 to October 2007 (Tab G-52 thru G-65). The MTP's training consisted of 93 hours of academic instruction and 16 hours of simulator missions (Tab G-52 thru G-63). The MTP's instructor pilots commented on his outstanding knowledge of F-22 systems (Tab G-55 thru G-63).

The mishap pilot's F-22 upgrade flight training began on 15 Oct 2007 and was conducted by the 411 FLTS at Edwards AFB, CA (Tab G-66 thru G-84). His training consisted of a ground engine run, three basic handling sorties, an aerial refueling sortie, an Advanced Handling Characteristics (AHC) sortie and an AHC simulator (Tab G-66 thru G-84). The MTP demonstrated excellent knowledge of F-22 handling qualities and flight control laws (Tab G-82). The MTP was commended for his response to an aircraft emergency compounded by a no radio situation during a Spot Evaluation checkride in November 2008 (Tab G-30, G-31). On 30

January 2009, the MTP completed his most recent Instrument Qualification checkride without discrepancy and was rated "Qualified" (Tab G-28).

b) Experience

Prior to the mishap, the MTP flew over 4,500 hours with the United States Air Force, the British Royal Air Force (RAF), and with Lockheed Martin as a pilot (Tab G-8, G-9). The MTP had 121 hours in the F-22A as a test pilot (Tab AA-9). He was a highly experienced operational pilot and test pilot with over 4,000 hours in the F-111, F-15-A/B/C/D/E, F-16C/D, F-117, T-38, C-12, F-22 and a variety of British aircraft. Additionally, he had over 1,000 hours of instructor time in various airframes (Tab G-5, G-9). The MTP attended the RAF Empire Test Pilot School and was actively involved in the flight test of multiple aircraft after graduating in December 1992 (Tab G-5, G-9). The MTP held a Bachelor of Science degree in Aeronautical Engineering from the United States Air Force Academy and a Master of Science degree in Mechanical Engineering from California State University - Fresno (Tab G-8).

The MTP was highly experienced and well-versed in flight test. Colleagues remember him as a competent, thoughtful, meticulous, and well-prepared test pilot (Tab V-3.7, V-6.5, V-7.3, V-10.5, V-11.2).

The MP's flight time during the 90 days before the mishap is as follows:

	30 Day	60 Day	90 Day
Hours (F-22A / F-16)	7.3 / 4.7	14.8 / 4.7	17.9 / 10.3
Sorties (F-22A / F-16)	4 / 4	7 / 4	10 / 7

(Tab G-3)

Crew qualifications were not a factor in this mishap.

9. MEDICAL

a) Qualifications

On 25 March 2009, the MTP and MCP were medically qualified for aviation duty. The MTP's most recent FAA Class II flight physical, performed on 7 April 2008, was current and complete at the time of the mishap. The MCP's flight physical was performed and recorded on an AF Form 1042 on 4 April 2008; it was current and complete at the time of the mishap. All maintenance members were medically qualified for duty at the time of the mishap.

b) Health

The AIB medical advisor reviewed the medical and dental records of the MTP, MCP and maintenance members. There is no indication the MCP's or the maintainers' health conditions contributed to the mishap. However, evidence suggests the MTP had a minor pre-existing illness, most likely a common cold. There was insufficient evidence to conclude the MTP was suffering from illness on the day of the mishap. The results of the MTP's 7 April 2008 physical examination indicated a healthy 48-year old male, without chronic illness or daily prescribed medications.

c) Pathology

According to the MTP's autopsy report, he expired instantly upon ejection from the MTA. He suffered multiple fatal blunt force injuries and secondary flail injuries due to high windblast forces (Tab X-9).

d) Toxicology

Immediately following the mishap, in accordance with AFI 91-204, *Safety Investigations and Reports*, the commander directed toxicology testing for all personnel involved in the MTA's 25 March launch and flight. Results of the MTP's post-mortem blood toxicology report indicate his carbon monoxide and ethanol levels were within acceptable limits (Tab X-5). Additionally, the MTP's blood sample tested negative for amphetamines, barbiturates, benzodiazepines, cocaine, cannaboids, opiates, and phencyclidine. The MTP's post-mortem urine screen yielded positive results for diphenhydramine (Tab X-7).

The MTP's urine tested positive for diphenhydramine, an antihistamine ingredient commonly found in over-the-counter cold medications. However, diphenhydramine was not detected in the MTP's blood (Tab X-7). A presence of diphenhydramine in the MTP's urine sample, but undetected in his blood sample, indicates a trace level incapable of impairing the MTP. The MTP's seemingly conflicting urine and blood results suggest the diphenhydramine was in the final stages of being excreted from the MTP's body. No legal or illegal substances were found to be causal or substantially contributory in this mishap.

Blood and urine samples collected from the MCP and maintenance crew were submitted to the Armed Forces Institute of Pathology (AFIP) for toxicological analysis. This testing included carbon monoxide and ethanol levels in the blood and drug testing of the urine. All blood test results were within allowable limits and all urine test results were negative for drugs.

e) Lifestyle

There was no evidence of unusual habits, behavior or stress on the part of the MTP, MCP or maintenance members contributed to this mishap. There were no lifestyle factors relevant to the mishap.

f) Crew Rest and Crew Duty Time

Air Force Instructions require pilots to have proper "pilot rest" prior to performing flight duties. AFI 11-202, Volume 3, *General Flight Rules*, defines normal pilot rest as a minimum 12-hour non-duty period before the designated flight duty period (FDP) begins. Its purpose is to ensure the pilot is adequately rested before executing flying duties and has the opportunity for eight hours of uninterrupted sleep.

The MTP's duty cycle leading up to the mishap mission indicates he had at least 12 hours of pilot rest and was within duty limitations per AFI 11-202. The MTP's spouse stated he was well rested but had a mild cold. The MTP's colleagues report he was alert, oriented, and behaving in his normal manner during the mishap mission brief. However, several colleagues also mentioned the MTP had a cough on 23, 24, and 25 March (Tab V-1.5, V-9.2, V-13.2).

10. OPERATIONS AND SUPERVISION

a) Operations

The 411 FLTS is a tight knit organization consisting of highly experienced active duty Air Force test pilots and engineers as well as civilian test pilots and engineers. The level of aviation and engineering experience present in the 411 FLTS exceeds that of the average operational Air Force F-22 squadron. Members of the 411 FLTS confirm that squadron morale was high prior to the mishap and there was obvious camaraderie amongst active duty, Lockheed Martin, Boeing pilots and engineers (Tab V-1.6, V-3.4, V-7.4, V-8.3, V-10.5). In March 2009, the 411 FLTS was conducting multiple systems tests simultaneously; however, squadron members considered it a moderate, or normal, operations tempo (Tab V-3.6, V-7.2). It did not negatively impact their ability to operate and fly safely (Tab V-3.6, V-7.2).

The 411 FLTS has a comprehensive and detailed ORM program. The ORM program is used in preparation for every 411 FLTS sortie. The program is designed to detect factors such as lack of sleep, sickness, personal issues, etc. that could potentially affect the pilot's ability to fly the mission (Tab V-3.3, V-7.2, V-10.5, V-11.3). These factors are addressed by a supervisor who may impose additional requirements before making a final determination whether a pilot is safe to fly (Tab V-3.3, V-7.2).

b) Supervision

The mishap sortie was flown as planned and briefed. The mishap test maneuvers were subject to multiple safety reviews and required simulator practice in preparation for the mission (Tabs V-16.2 thru V-16.3, AA-20 thru AA-21). Reviews of the mishap maneuvers were accomplished along with the simulator practice. Additionally, these types of loads tests are not new to the F-22 test community; the same tests were executed previously without incident (Tab V-1.4). Specifically, another weapon was tested under very similar conditions – the same high airspeeds, the same g-loading, and similar altitudes (Tab V-12.6).

It is clear that both active duty and civilian test pilots fall under a single chain of command and respect the 411 FLTS Commander as the final authority (Tab V-11.8). The 411 FLTS Commander in turn recognizes the extensive knowledge and experience present in the Lockheed Martin and Boeing test pilots. Squadron leadership is thoroughly engaged in the oversight of tests conducted within the 411 FLTS and in the oversight of its pilots (Tab V-3.6).

11. HUMAN FACTORS ANALYSIS

The DoD Human Factors Analysis and Classification System (DOD HFACS, dated 11 January 2005) includes a list of potential human factors that can contribute to a mishap. Analysis indicates human error is identified as a causal factor in 80 to 90 percent of mishaps. Human factors, are, therefore, the greatest mishap hazard (DOD HFACS, 11 January 2005).

Human factors affect an individual's situational awareness (SA). SA is a continuous perception of self and aircraft in relation to the dynamic environment of flight, threats, missions, and the ability to anticipate, and then execute tasks based on that perception (AFI 11-290). If an aviator loses SA, it means he no longer has an accurate perception of the flight environment and he begins to misprioritize tasks based on this misperception. An aviator may never be aware that he has lost SA until an outside stimulus (e.g. aircraft warning signs, another person, or an environmental cue) alerts him. A pilot may never regain SA and consequently places the aircraft in a dangerous situation.

The human factors relevant to this mishap that potentially affected the MTP's SA are: Adverse Physiological States -- Effects of G-Forces (acceleration cardiovascular effects (ACE), grayout, etc), Physical Fatigue (Overexertion), Pre-Existing Physical Illness, Skill-Based Errors – Inadequate Anti-G Straining Maneuver, and Cognitive Factors -- Channelized Attention, Distraction, Negative Transfer (Habituation).

a) Effects of G Forces (G-LOC, A-LOC, etc)

The effect of g-forces is a factor when a pilot experiences g-induced loss of consciousness (G-LOC), grayout, blackout or other neuro-circulatory effects of sustained acceleration forces (DOD HFACS, 11 Jan 05).

A-LOC is a transient incapacitation, without loss of consciousness, which occurs during and after short-duration, rapid-onset g-forces. A-LOC is characterized by unresponsiveness to voice communication and loss of numerical skills, with various degrees of memory compromise and may include transient paralysis and convulsive motor activities. A-LOC is considered to be part of the G-LOC syndrome. (Tab X-11)

Acceleration resulting in g-forces is one of the major physical stresses associated with flight in high-performance aircraft. Acceleration effects include increased weight of head and extremities, sagging of soft tissue, spinal compression, and increased pressure requirements of the cardiovascular system to keep blood flowing throughout the body. During g-onset, cardiovascular reflexes initially compensate, providing approximately 1 g of protection, but eventually visual degradation occurs and progresses to loss of consciousness. Rapid g-onset at higher acceleration rates requires voluntary anti-g straining maneuvers (tensing leg, buttocks, and abdominal muscles) combined with respiratory maneuvers to increase intra-thoracic (chest) pressure, as well as requires use of protective gear to increase tolerance and maintain vision and consciousness. Many factors can significantly reduce g-tolerance, including but not exclusive of: general fatigue, recency of training/operations, sleep deprivation, medication, and any form of illness.

Physiological effects of g-loads vary with the magnitude of acceleration, duration, direction of g-forces, and location of application to the body. Such forces impact the body in different ways. When a body is accelerated from the head down, it experiences positive g (+Gz), which pushes the body into the seat, draining blood from the head toward the lower parts of the body. It becomes difficult to breathe as the ribs and internal organs are pulled down, emptying air from the lungs. The condition is physically demanding as blood has to be pumped harder by the heart and muscles to reach the brain. The brain and eyes require oxygenated blood to function and are affected as blood drains from the head. At approximately 2-3 g's, blood supply to the head decreases and degrades vision. The eyes first lose peripheral vision, creating a tunnel vision effect until complete vision loss/blackout. The body attempts to maintain cerebral blood pressure to sustain consciousness, but if g-forces remain constant, unconsciousness will occur. The unconscious state induced by g-forces is known as G-LOC (G-induced Loss of Consciousness). As g is reduced, blood flow returns to the brain, and vision and consciousness are regained.

The effect of g-forces are a factor in this mishap because the test mission consisted of three test maneuvers with high g-force exposures. The MTP sustained high g for an average of 15 seconds during each test and subsequent recovery. Based on g-forces encountered, the mishap mission qualified as a physically demanding mission (Tab V-1.3, V-1.6). The MTP's comment, "oh man" four seconds after reducing gs on the second test maneuver further affirms that he was challenged by g-forces during the test maneuvers (Tab N-13).

During the mishap test maneuver, the MTP did not execute a proper anti-g straining maneuver as assessed by his breathing technique (AGSM) (Tab X-3). The MTP's AGSM is characterized by labored grunts, groans, and a near continuous exhalation. There was a progressive breakdown in his AGSM technique during each successive test maneuver. Evidence suggests that during the mishap maneuver, the MTP was struggling to maintain consciousness and may have experienced neuro-circulatory effects of sustained acceleration forces including grayout, light loss, tunnel vision, and "almost g-induced loss of consciousness" (A-LOC) (Tab X-3).

The MTP did not experience G-LOC because throughout the mishap test maneuver he continued to command the MTA (based on presence of stick inputs) and made a distressed statement just prior to ejection; therefore, he was conscious, but was nevertheless relatively incapacitated by the acceleration forces (Tab X-3). The MTP eventually recognized the unsafe attitude, altitude, and airspeed of the MTA and initiated ejection outside the limits of the ACES II design envelope. During ejection, the MTP experienced windblast forces and seat deceleration forces (+60/-30Gz) in excess of those seen in ejection seat testing (Tab DD-32).

b) Inadequate Anti-G Straining Maneuver

An inadequate Anti-g Straining Maneuver is a factor when the individual's AGSM is improper, inadequate, poorly timed or non-existent and this leads to adverse neuro-circulatory effects (DOD HFACS, 11 Jan 05).

There are two aids to prevent G-LOC, the upper/lower body g-suit and the AGSM. A g-suit is a garment worn over the flight suit. It has bladders which inflate with air, squeezing the legs and abdomen to reduce the amount of blood forced away from the head. The g-suit aids the pilot's AGSM by squeezing the already tensed muscles of the legs, buttocks, and abdomen. Accelerations up to 9 g's can be tolerated for a longer period of time with a g-suit. AGSM training teaches pilots to flex the calf, thigh, buttocks, and abdominal muscles while crisply inhaling and holding the breath, then rapidly exhaling and exchanging air at 3 second intervals to maintain adequate intra-thoracic (chest) pressure. An effective AGSM squeezes the heart and keeps blood flowing to the head.

Audio recording of the MTP's AGSM during the mishap mission was evaluated post-mishap by an aerospace physiologist who characterized the MTP's AGSM technique as improper (Tab X-3). During the first two test maneuvers, the MTP performed an AGSM characterized by long grunting air exchanges at 5-6 second intervals. In the mishap test maneuver, there is no audible inhalation, but the MTP can be heard continuously grunting expirations (Tab X-3). The MTP's improper AGSM technique compromised adequate intra-thoracic (chest) pressure, which caused degradation of his vision. Because of this degradation in vision the MTP's attention became channelized on remaining conscious and he subsequently lost SA on the MTA's altitude, airspeed, and dive angle.

By comparison, the MTP demonstrated similar improper AGSM technique based on an audio recording of his previous high-g test mission dated 23 March 2009 (Tab AA-23) The MTP's most current AGSM evaluation and training occurred on 31 Jan 2007 at a USAF centrifuge training facility at Holloman AFB prior to transition into the F-16 (Tab G-105, G-106). The MTP was rated average during his centrifuge evaluation. Average rating is defined as "AGSM performance had not been mastered fully and minor AGSM performance errors impact AGSM technique" (Tab G-105). AGSM qualification training in the F-16 qualified the MTP to fly other high-g aircraft, like the F-22.

c) Channelized Attention

Channelized Attention is a factor when the individual is focusing all conscious attention on a limited number of environmental cues to the exclusion of others of a subjectively equal or higher or more immediate priority, leading to an unsafe situation. [It] may be described as a tight focus of attention that leads to the exclusion of comprehensive situational information (DOD HFACS, 11 Jan 05).

During the first two test maneuvers, the MTP set up, then inverted the MTA, executed a split-S to achieve test parameters within the test band and recovered immediately thereafter (Tabs V-1.3, AA-17, AA-18). However, on the mishap test maneuver, the MTP deviated from the similar previous maneuvers by continuing to pull the MTA through the test band into a steep dive (Tab DD-128).

Channelized attention is relevant to this mishap given that the MTP exhibited ineffective AGSM during the mishap maneuver and therefore had to fight off symptoms of A-LOC to maintain SA. Within seconds of initiating the mishap test maneuver, the MTP achieved test parameters and could have started recovery. However, he delayed, passed through the test band, continued to descend and the MTA positioned in a steeper and more dangerous dive angle. The MTP's delayed response occurred because his attention was focused solely on fighting the symptoms of A-LOC by executing a more vigorous AGSM (Tab X-3). The MTP's channelized attention in turn led to a loss of SA regarding the MTA's orientation.

At 1701:50Z/1001:50L, the MTP rolled inverted and began the third test maneuver (Tab N-16). He opened the left SWB door 1,360 ft early, at 24,160 ft MSL (Tab DD-138). Given the challenging nature of this test it is plausible the MTP mistakenly opened the door early; however, it could also indicate he was succumbing to the effects of g-forces. The MTP continued to pull as the MTA descended through the test band and the nose of the aircraft progressed to a steeper dive angle.

The MTP executed a labored and strained AGSM (Tab V-1.5). Nine seconds after initiating the maneuver, the MTP pulled the throttles to idle power but did not initiate an effective roll upright, which would have halted the MTA's descent. The MTA was 19,890 ft MSL, traveling at supersonic speed, 65-degrees nose low, high g's and at an extremely high descent rate (Tab DD-138).

There was significant deviation between execution of the first two test maneuvers and the mishap test maneuver in terms of pitch attitude and altitude in relation to the MTP's initiation of recovery. In the previous two test maneuvers, the MTA never exceeded a -55 degree pitch attitude, whereas the MTA continued to steepen to 83 degrees nose low on the mishap test maneuver (Tab DD-138). Additionally, in the previous test the MTP pulled the throttles to idle power and rolled the MTA upright 2,140 ft higher than in the mishap test maneuver (Tab DD-138, DD-140). In the first two test maneuvers the MTP recovered by simultaneously pulling the throttles to idle while rolling the aircraft to an upright attitude and then pulling out of the dive created by the half split-S (Tab DD-140). In contrast, during the mishap maneuver the MTP delayed initiation of this roll to upright for four seconds, during which time the MTA lost 6,000 ft of altitude and reached its steepest dive angle of 83 degrees nose low (Tab DD-138). Delayed response time at the MTA's steeper dive angle, lower altitude, and lack of an aggressive roll to an upright position after achieving test parameters indicates the MTP was suffering from the physiological effects of A-LOC, had channelized attention and loss of SA.

Four seconds elapsed from when the MTA was within the test band to this extremely nose low position. The MTA was pointed nearly straight down at a very high airspeed and descent rate. The MTP rolled the MTA towards upright and because he continued to pull the nose of the MTA up, he reached a descent angle of approximately 50-degrees nose low (Tab DD-138). This reduced pitch angle lowered the MTA's Mach number and the g-forces experienced by the MTP. A reduced g, paired with the MTP's focused efforts to execute an AGSM enabled the MTP to regain enough vision and SA to recognize the dangerous attitude of the MTA. In response, the MTP shouted a distressed comment, released the controls of the MTA and reached for the ejection seat handle (Tabs DD-138, N-13).

At the time the MTP released the controls, the MTA was at 7,486 ft MSL, right side up at 53 degrees nose low, supersonic airspeed, high g-loading, with a significant descent rate (Tab DD-138). While at the ideal recovery altitude, the MTP was so focused on fighting symptoms of A-LOC and maintaining consciousness, that he lost SA due to grayout and channelized attention on performing the AGSM. Because of this, the MTP failed to maintain a cross-check of the MTA's airspeed, altitude, dive angle, which placed the MTA in an unrecoverable position, and he was forced to eject.

d) Physical Fatigue (Overexertion)

Physical Fatigue (Overexertion) is a factor when the individual's diminished physical capability is due to overuse (time/relative load) and it degrades task performance (DOD HFACS, 11 Jan 05).

Physical fatigue is relevant to the discussion of this mishap, but due to insufficient evidence it did not rise to be a contributory factor. Fatigue was initially considered a factor because the mishap mission test profile required a series of physically demanding high g maneuvers and the mishap occurred during the third maneuver. Additionally, the MTP may have been experiencing a pre-existing illness and he was performing an improper AGSM, which merely suggests, but is not indicative of, exacerbated fatigue due to exertion. Beyond circumstantial speculation, there was no affirmative evidence fatigue was causal or a contributory factor in this mishap.

e) Pre-Existing Physical Illness

Pre-Existing Physical Illness/Injury/Deficit is a factor when a physical illness, injury or deficit that existed at the time the individual boarded the aircraft or began the mission/task causes an unsafe situation... (DOD HFACS, 11 Jan 05).

Pre-existing physical illness is relevant to the discussion of this mishap; however, due to insufficient evidence it did not rise to a contributory factor. The MTP may have suffered from a minor illness, perhaps a common cold, at some point prior to the mishap. According to non-medically qualified witness testimony, the MTP was heard coughing days prior to the mishap mission as well as the day of the mishap (Tab V-1.5, V-9.2, V-13.2). However, there is no record the MTP received medical treatment from either a military flight surgeon or his civilian doctor. A post-mishap toxicology report revealed trace evidence of diphenhydramine (an ingredient in non-prescription cold medication) in the MTP's urine sample, but it was absent from his blood sample (Tab X-7). Trace presence of medication in urine, but undetected in blood is an indication the substance is being expelled from the body. At such a low level, the medication would not impair pilot performance but its presence in his body is evidence of a pre-existing illness. These circumstances suggest the MTP may have taken medication at some point, but it is unclear when he took medication and whether he was suffering from illness at the time of the mishap. According to medical experts, illness reduces an individual's tolerance to g-force. However beyond expert opinion, there is no evidence confirming whether the MTP was sick at the time of the mishap and, if so, that his illness caused or contributed to the mishap event.

f) Distraction

Distraction is a factor when the individual has an interruption of attention and/or inappropriate redirection of attention by an environmental cue or mental process that degrades performance. (DOD HFACS, 11 Jan 05)

Distraction is relevant, but neither a causal or contributory factor in the mishap. Distraction was considered because the left IRCM door opened unexpectedly when the MTP purposefully opened the left SWB doors during the first two test maneuvers (Tab DD-120). The IRCM door opening during tests was initially considered a potential distraction during the mishap maneuver since the incident commanded the MTP's attention during refueling (Tab N-13, N-14). While refueling, the MTP commented that perhaps his pencil or kneeboard was inadvertently activating the IRCM door (Tab N-14). However, the MCC pacified the MTP's concern by responding that the IRCM door opening did not affect MTA performance or test point validity (Tab N-12, N-13). Although conceivably a distraction, it is unlikely the MTP, given his test pilot experience, would become distracted by an event deemed inconsequential with respect to the mission. Furthermore, if the MTP was remotely concerned about the position of the IRCM door, he need only glance down at the display to check the door status. Consequently, distraction associated with the IRCM doors was neither causal nor contributory in this mishap.

g) Negative Transfer (Habituation)

Negative Transfer is a factor when the individual reverts to a highly learned behavior [habit pattern] used in a previous system or situation and that response is inappropriate or degrades mission performance." (DOD HFACS,11 Jan 05)

On 25 March 2009, during the first two test maneuvers the MTP initiated recovery simultaneously with or immediately following a “point complete” call from the TC. However, during the third maneuver, a “point complete” call was not made (Tab N-16). Nine seconds after initiating the maneuver the MTP pulled the MTA throttles to idle, at 19,890 ft MSL, indicating that he was no longer conducting the test maneuver (Tab DD-138). Within a few seconds he took additional (but delayed and insufficient) recovery actions (Tab DD-138). These delayed actions indicate the MTP had lack of SA. However, given the MTP’s initial action of putting the MTA throttles in idle, the subsequent delay did not indicate that he was waiting for a “point complete call”. Compared to the previous two test maneuvers, the delayed, insufficient MTA recovery ultimately prevented a safe recovery.

In accordance with *AFFTCI 99-105, 1 Apr 2008*, the radio call “point complete” is not a requirement. However, it is a “standard practice” in the test community (Tab V-12.10). The call is not directive, but rather informative and is called to let the pilot know the test point parameters have been achieved for that respective test (Tab AA-26).

411 FTS pilot interviews confirm aircraft recovery is NOT dependent on hearing “point complete,” rather the pilot recovers upon departure from the test band or if required for safety purposes (Tab V-11.3, V-11.4, V-12.10). Comparison of the MTP's previous 23 March test mission did not validate whether the MTP had developed the habit of waiting until "point complete" was called before initiating recovery. During the 23 March mission, “point complete” was called after the MTP executed each of six test maneuvers (Tab AA-23). The MTP recovered simultaneously or immediately after achieving test parameters on every maneuver. However, the 23 March test profile allowed ample opportunity at lower g-loadings to recover the aircraft, which sharply contrasts the 25 March maximum g-profile.

Given the disparity between the 23 March and 25 March profiles and the limited number of maneuvers during the mishap mission to establish a pattern, there is no evidence the MTP habitually waited for the TC to report “point complete”. Nor does evidence suggest the MTP relied solely on the radio call to initiate aircraft recovery. It is plausible, but there is no definitive evidence, that a “point complete” call could have served as an auditory stimulus causing the MTP to regain SA. Although AFFTCI 90-105 provides for monitoring of safety of flight information, the evidence does not indicate that MCC personnel had adequate time to influence the MTP’s actions (Tab V-1.5, V-12.8). Negative transfer **(**Habituation) has been ruled out as having any causal or contributory significance in the mishap.

12. GOVERNING DIRECTIVES AND PUBLICATIONS

There are no known or suspected deviations from directives or publications by the MTP or others involved in the mishap mission.

a) Primary Operations Directives and Publications.

1. AFI 11-202, Volume 3, *General Flight Rules*, 5 April 2006
2. AFI 51-503, *Aerospace Accident Investigation*, 16 July 2004
3. AFI 91-204, *Safety Investigation and Reports*, 24 September 2008
4. AFI 11-401, *Aviation Management*, 7 March 2007
5. AFI 11-290, *Cockpit/Crew Resource Management Training Program*, 11 April 2007
6. AFI-2FT, Volume 3, *Flight Test Operations Procedures*, 19 September 2007
7. *F-22A Risk Reduction Captive Carriage Test*
8. DoD Human Factors Analysis and Classification System, 11 January 2005

b) Maintenance Directives and Publications.

T.O. 1F-22A(EMDAV)-1, *F-22A Flight Manual*, 12 November 2007

c) Known or Suspected Deviations from Directives or Publications.

There are no known or suspected deviations from directives or publications by crew members or others involved in the mishap mission.

13. NEWS MEDIA INVOLVEMENT

Following the mishap, media interest related to the incident was high. Local, national, and international media outlets immediately reported on the mishap (Tab CC-3 thru CC-6). The Edwards AFB Public Affairs office posted articles pertaining to the mishap and the MPT's memorial service on the base website. A Los Angeles Times obituary article outlined the MTP's career accomplishments and notified the public of funeral services (Tab CC-7).

D. Eidsaune

15 July 2009

DAVID W. EIDSAUNE
Major General, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

F-22A, T/N 91-4008 ACCIDENT
25 MARCH 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

The mishap mission was a Risk Reduction Captive Carriage Test on an F-22A aircraft. The overall test objective was to gather flight test data on how the weapons integration affects aircraft performance by flying loads, flutter, vibroacoustic, and thermal test points. The mishap test aircraft (MTA) carried the test weapon and was instrumented to transmit flight data to the Ridley Mission Control Center (MCC) for real-time and post-flight analysis. MCC personnel coordinated with and monitored the mishap test pilot (MTP) while he performed test maneuvers on specific configurations and parameters in the MTA's flight envelope.

The MTA was destroyed upon impact and, therefore, minimal useful post-mishap physical evidence was recovered. However, telemetry data collected by the MCC coupled with witness interviews, consultation with experts, results of technical analyses, computer and simulator modeling, and examination of relevant medical, training and maintenance documents provided sufficient evidence for this investigation.

Based on a review of maintenance training records, MTA telemetry data, and MTA maintenance records, with particular focus on MTA maintenance actions accomplished within the 90 day period prior to the mishap, it was determined MTA structure and systems malfunctions did not contribute to this mishap. In addition, data recovered from the MTA's Crash Survivable Memory Unit (CSMU) validated telemetry data collected by the MCC.

Medical experts reviewed the MTP's complete medical history, post-mishap toxicology test results, autopsy findings, and investigated potential human factor contributions such as: situational awareness, effects of acceleration forces, anti-g straining maneuver (AGSM) performance, channelized attention, fatigue, and illness.

I find by clear and convincing evidence this mishap was caused by the MTP's adverse physiological reaction to high acceleration forces, resulting in channelized attention and loss of situational awareness (SA) during recovery from a test maneuver. The MTP regained partial SA and attempted a late recovery from the test maneuver, but he determined there was inadequate altitude for a safe recovery and ejected. The ejection was attempted outside the ejection seat envelope, resulting in the MTP's death.

2. DISCUSSION OF OPINION

a) Background

The mishap mission proceeded as briefed through the first two test maneuvers (points 18.1 and 18.2) and air refueling. The mishap test maneuver (18.3) was attempted after refueling. Desired test parameters for all three points were Mach 1.60 +/-.02 at an altitude of 20,800 +/-2000 Feet (ft) MSL. Achieving the target g within these parameters completed the test point. 18.1 was a buildup point to near max target g-forces and 18.2 was flown at max target g. Both of these test points were entered with the left Side Weapons Bay (SWB) door open. 18.3 would differ from 18.1 and 18.2 in that the left SWB would be opened upon reaching test parameters. The flight test technique to achieve test parameters was a wind-up turn in the vertical plane (split S) and was the same for test points 18.1, 18.2 and 18.3. In fact, that is how it was rehearsed in the simulator by the MTP and two other test pilots on 17, 19, and 24 Mar 09.

Test point 18.2 was executed as planned. Target g was reached at 22,400 ft MSL and Mach 1.6, at which time, the MTP rolled to wings level and continued a high g pull to recover at 13,600 ft MSL. Pitch attitude never exceeded 55 degrees nose down during the test maneuver and recovery.

Test point 18.3 started in a similar manner as 18.2. The left SWB door was cycled open at 24,060 ft MSL (~1200 ft above the planned altitude band) and the target g was reached entering the top of the altitude band (22,800 ft MSL) at Mach 1.6. At this point, the MTP achieved test parameters and could have initiated recovery. However, the MTP continued a high g pull to a dive angle of 83 degrees nose down. An ineffective, weak roll to wings level was started at 18,770 ft MSL, but at this point, with the extreme nose down attitude, the roll was simply a pirouette around the vertical axis with little effect on arresting the descent rate. At 14,640 ft MSL (7520 ft below the previous test point), a full roll stick input was initiated to wings level but the dive angle at this point was still 83 degrees nose down at an airspeed of 779 KCAS. The MTP continued a full aft stick pull up to approximately 50 degrees nose down, but at 7486 ft MSL (~5000 ft above ground level (AGL), he determined sufficient altitude was not available for a safe recovery (confirmed through simulation) and he ejected. The MTP initiated ejection 165 knots above the modified Advanced Concept Ejection Seat (ACES II) design limit and suffered fatal injuries due to blunt force trauma caused by windblast.

b) Cause

The cause of the mishap was the MTP's adverse physiological reaction to high acceleration forces, resulting in channelized attention and loss of situational awareness (SA) during recovery from a test maneuver. Re-enactment of the mishap event in the simulator and computer modeling indicate this high g, high speed, edge-of-the-envelope maneuver left little room for error. However, when properly executed, the recovery altitude was consistently 10,000 ft AGL and higher, as demonstrated in the simulator and on the previous points 18.1 and 18.2.

Based on recorded cockpit audio and the presence of stick inputs throughout the maneuver and recovery, the MTP did not experience a total g-induced loss of consciousness (G-LOC), but was still significantly impaired by the acceleration forces and experienced suspected severe levels of grayout, light loss, and/or tunnel vision. Physiologists term this type of incapacitation "almost g-induced loss of consciousness" (A-LOC). Audio recording of the MTP's AGSM during the mishap maneuver indicate the MTP struggled to maintain consciousness during the recovery. The less-than-effective AGSM failed to combat the physiological effects of the acceleration forces in a timely manner. While channelizing his attention in an attempt to remain conscious, the MTP lost situational awareness (SA) regarding the MTA's altitude, airspeed and dive angle, and within seconds, he found himself in an unrecoverable aircraft attitude. The delayed, but correct, aggressive roll to wings level, max g pull to the horizon, and an audible comment coupled with the decision to eject, suggests the MTP was recovering from some A-LOC symptoms and regaining SA, but the altitude remaining was not sufficient for a safe recovery.

The AIB thoroughly researched all other possible factors that could have substantially contributed to this mishap. The following were investigated and were determined not to be factors in this mishap: weather, pilot experience, pilot qualifications, operations tempo, supervision, maintenance documentation/inspections, life style and crew rest issues, mission preparation/briefing, and aircrew flight equipment. Although very little physical evidence was recovered from the mishap site, the recorded telemetry data and audio were critical to ruling out all other possible causes.

D. Eidsaune

15 July 2009

David W. Eidsaune
Major General, USAF
President, Accident Investigation Board