UNITED STATES AIR FORCE AIRCRAFT ACCIDENT INVESTIGATION BOARD REPORT

F-16CM, T/N 88-0510

31ST FIGHTER WING
AVIANO AIR BASE, ITALY

LOCATION: NEAR CERVIA, ITALY

DATE OF ACCIDENT: 28 JANUARY 2013

BOARD PRESIDENT: BRIG GEN DEREK P. RYDHOLM

CONDUCTED IAW AIR FORCE INSTRUCTION 51-503

EXECUTIVE SUMMARY

AIRCRAFT ACCIDENT INVESTIGATION

F-16CM, T/N 88-0510
NEAR CERVIA, ITALY
28 JANUARY 2013

On 28 January 2013, at approximately 1903 hours local time (L), an F-16CM, tail number 88-0510, assigned to the 510th Fighter Squadron, 31st Fighter Wing, Aviano Air Base (AAB), Italy, departed AAB as part of a formation of three F-16CM and one F-16DM aircraft engaged in a night training mission. The pilots were using night vision goggles (NVGs). Prior to the mishap, after airspace weather precluded them from achieving their primary mission, the mishap pilot (MP) and mishap wingman (MW) coordinated two simulated bomb attacks as a backup mission. The first attack, which did not include any simulated defensive threat reactions, was executed without event. At 1948L, approximately 45 minutes after takeoff, the MP executed a threat reaction which culminated in a "last ditch" defensive maneuver. This occurred during post-attack egress on the second attack and initially resulted in the mishap aircraft (MA) entering a 45 degree nose low, 90 degree left wing down, attitude. Approximately 12 seconds later, the MP transmitted he was spatially disoriented.

At the prompting of the MW to transition to internal aircraft instruments, the MP attempted a recovery maneuver. The execution of the "last ditch" maneuver and follow on recovery maneuvers resulted in aural warnings and caution lights illuminating inside the aircraft, loss of all cultural lighting cues and discernible horizon outside the aircraft, and unusual aircraft attitudes, which together led to a high rate of descent and airspeed. The MP was spatially disoriented to the point where he believed that he could not recover the MA. At approximately 19:49:24L, the MP initiated ejection. The MP suffered fatal head and neck trauma during ejection. The MA was destroyed upon impact in the Adriatic Sea, approximately four miles from the ejection site. The loss of the MA and its associated property is valued at $28,396,157.42. There was no other damage to government or private property.

The Accident Investigation Board President found, by clear and convincing evidence, that the cause of the mishap was the MP's failure to effectively recover from spatial disorientation, due to a combination of weather conditions, the MP's use of NVGs, the MA's attitude and high rate of speed, and the MP's breakdown in visual scan. This led the MP to misjudge the imminent need to eject. The Board President also found, by clear and convincing evidence, that an immediate loss of the MP's helmet upon the high-speed ejection, slack in the ejection seat harness, and a left yaw to the ejection seat as it left the MA, along with a 40 gravitational force snapback that followed the ejection seat's drogue chute deployment, caused the MP's injuries, which quickly resulted in his death.

SUMMARY OF FACTS AND STATEMENT OF OPINION
F-16CM, T/N 88-0510
28 January 2013

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COMMONLY USED ACRONYMS AND ABBREVIATIONS

3 AF	Third Air Force
31 FW	31st Fighter Wing
31 FSS	31st Force Support Squadron
31 OG	31st Operations Group
162 FS	162nd Fighter Squadron
510 FS	510th Fighter Squadron
555 FS	555th Fighter Squadron
4V2	Four Friendly Against Two Enemy Aircraft
AAB	Aviano Air Base
AB	Afterburner
ACCES	Attenuating Custom Communications Earpiece System
ACES II	Advanced Concept Ejection Seat II
ACM	Air Combat Maneuver
ADI	Attitude Director Indicator
ADO	Assistant Director of Operations
AETC	Air Education Training Command
AF	Air Force
AFAFRICA	Air Forces Africa
AFB	Air Force Base
AFE	Aircrew Flight Equipment
AFI	Air Force Instruction
AFIP	Air Force Institute of Pathology
AFMAN	Air Force Manual
AFMES	Armed Forces Medical Examiner System
AFP	Augmenter Fuel Pump
AFPAM	Air Force Pamphlet
AFRICOM	Africa Command
AFSC	Air Force Specialty Code
AFTO	Air Force Technical Order
AFTTP	Air Force Tactics, Techniques, Procedures
AGE	Aerospace Ground Equipment
AGL	Above Ground Level
AGSM	Anti-G Straining Maneuver
AIB	Accident Investigation Board
AIM	Air Intercept Missile
ALO	Air Liaison Officer
ALOW	Altitude Low
AMXS	Aircraft Maintenance Squadron
A/P	Autopilot
ARMS	Aviation Resource Management System
ASOS	Air Support Operations Squadron
ATC	Air Traffic Control
ATG	Adversary Tactics Group
AUTO	Automatic
AUX	Auxiliary
BAC	Blood Alcohol Concentration
B Course	Basic Qualification Course
BFM	Basic Fighter Maneuver
BINGO	Minimum Fuel Required to RTB
Blue Air	Friendly Aircraft
BMC	Basic Mission Capable
BPO	Basic Post-Flight Inspection
BOC	Bombs on Coordinates
Capt	Captain
CAF	Combat Air Forces
CAPs	Critical Action Procedures
CARA ALOW	Combined Altitude Radar Altimeter Altitude Low
CATM	Captive Air Training Missile
CCIP	Common Configuration Implementation Pgm
Cert	Certification
CGO	Company Grade Officer
COMBAT EDGE	Combined Advanced Technology Enhanced Design G Ensemble
COMM	Communication
CONUS	Continental United States
CP	Command Post
Dash One	AFTO 1F-16C-1 Flight Manual
DFLC	Digital Flight Computer
DO	Director of Operations
DODHFACS	Department of Defense Human Factors Analysis and Classification
DRS	Digital Recovery Sequencer
DTC	Data Transfer Cartridge
DVR	Digital Video Recorder
ECM	Electronic Counter Measures
ELT	Emergency Locator Transmitter
EFT	Engine Flight Time
EOR	End of Runway
EP	Emergency Procedures
ER	Exceptional Release
EUCOM	European Command
F-16CM	Single Seat CCIP Modified F-16
F-16DM	Dual Seat CCIP Modified F-16
F	Fahrenheit
FAST	Fatigue Avoidance Scheduling Tool
FCIF	Flight Crew Information File
FCR	Fire Control Radar
FDP	Flight Duty Period
FERMS	Flight Equipment Records Management System
FLCS	Flight Control System
FLUG	Flight Lead Upgrade
FS	Fighter Squadron
FSS	Force Support Squadron
FTU	Flying Training Unit
G	Gravitational Force
G-LOC	G-Induced Loss of Consciousness
G-Suit	Anti-G Garment
GAAF	Ground Avoidance Advisory Function
GCAS	Ground Collision Avoidance System
GPS	Global Positioning System
HF	Human Factor

HMCS	Helmet-Mounted Cueing System
HUD	Head-up Display
IAW	In Accordance With
IFF	Introduction to Fighter Fundamentals
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
IMDS	Integrated Maintenance Data System
IRC	Instrument Refresher Course
ITAF	Italian Air Force
IP	Instructor Pilot
IPUG	Instructor Pilot Upgrade
JDAM	Joint Direct Attack Munitions
JMP	Joint Mission Planning
JOAP	Joint Oil Analysis Program
K	Thousand
L	Local Time
LASDT	Low Altitude Step-Down Training
LAU	Launch Adaptor Unit
LIS	Line-in-the Sky
LOX	Liquid Oxygen
LPU	Life Preserver Unit
Lt Col	Lieutenant Colonel
MA	Mishap Aircraft
Maj	Major
MAJCOM	Major Command
MAN	Manual
MAU	Munitions Adapter Unit
MDS	Mission Design Series
ME	Mishap Engine
MF	Mishap Flight
MFD	Multi-function Display
MFL	Maintenance Fault List
MIL or MIL POWER	Military Power
mmHg	millimeters of Mercury
MOA	Military Operating Area
MP	Mishap Pilot
MPS	Mishap Pilot Spouse
MQT	Mission Qualifying Training
MS	Mishap Sortie
MSL	Mean Sea Level
MW	Mishap Wingman
NATO	North Atlantic Treaty Organization
NCOIC	Non-Commissioned Officer in Charge
NOTAMS	Notices to Airmen
NSI	Nuclear Surety Inspection
NVGs	Night Vision Goggles
OFP	Operational Flight Program
OG	Operations Group
OPR	Officer Performance Report
OPSAT	Opposed Surface Attack Tactics
Ops Tempo	Operations Tempo
ORM	Operational Risk Management
OSS	Operation Support Squadron

OTS	Over-the-Side
PCS	Permanent Change of station
PERCH	Set up for an Engagement
PFL	Pilot Fault List
PGCAS	Predictive Ground Collision Avoidance System
PHA	Periodic Health Assessment
PLB	Personnel Locator Beacon
PR	Preflight
PRD	Pilot Reported Discrepancy
QA	Quality Assurance
QUAL	Qualification
RAF	Royal Air Force
RAPCON	Radar Approach Control
Red Air	Enemy Air Threat
RED X	Safety of Flight
RTB	Return-To-Base
RTU	Replacement Training Unit
SADL	Situational Awareness Data Link
SAM	Surface-to-Air Missile
SAR	Search and Rescue
SATAF	Sight Activation Task Force
SD	Spatial Disorientation
SDR	Seat Data Recorder
SEFE	Standardization Evaluation Flight Examiner
SERE	Survival Evasion Resistance Escape
SIB	Safety Investigation Board
SMS	Stores Management System
S/N	Serial Number
SOF	Supervisor of Flying
Sortie	Flight
SRD	Summary of Recorded Data Sources
TACAN	Tactical Aid to Navigation
TCI	Time Change Inspection
TCTO	Time Compliance Technical Order
TDY	Temporary Duty
TH	Thru-Flight
TI	Tactical Intercept
TLP	Tactical Leadership Program
T/N	Tail Number
TO	Technical Order
TOP 3	Operations Supervisor
Tox Screening	Toxicology Screening
TR	Training Rules
TX	Transition Course
UHF	Ultra High Frequency
URITS	USAFE Rangeless Interim Training System
US	United States
USAFE	United States Air Forces Europe
U.S.C.	United States Code
USAF	United States Air Force
UTC	Coordinated Universal Time
UWARS	Universal Water Activated Release System

VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
VUL	Vulnerability Time
WIC	Weapons Instructor Course
WOW	Weight on Wheels
Z	Zulu or Greenwich Mean Time

SUMMARY OF FACTS

1. AUTHORITY AND PURPOSE

a. Authority

On 1 February 2013, Lieutenant General Noel T. Jones, Vice Commander, United States Air Forces in Europe (USAFE) appointed Brigadier General Derek P. Rydholm to conduct an aircraft accident investigation of the 28 January 2013 mishap of an F-16CM aircraft, tail number (T/N) 88-0510, over the Adriatic Sea, near Cervia, Italy. The aircraft accident investigation was conducted IAW Air Force Instruction (AFI) 51-503, *Aerospace Accident Investigations*, and was convened at Aviano Air Base (AAB), Italy, from 1 March 2013 through 26 March 2013. The Accident Investigation Board (AIB) members then continued to work on the board report from their regular duty locations and completed their work on 2 August 2013. The following board members were also appointed: Colonel Legal Advisor, Lieutenant Colonel (Lt Col) Medical Member, Lt Col Physiologist/Human Factors Member, Major Pilot Member, First Lieutenant Maintenance Member, Technical Sergeant Aircraft Flight Equipment/Life Support Member, and a Master Sergeant Recorder. A Lt Col Italian Air Force observer, who was also the host nation liaison, was appointed (Tab Y-1 to Y-9).

b. Purpose

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

2. ACCIDENT SUMMARY

The mishap aircraft (MA) an F-16CM, T/N 88-0510, was assigned to the 510th Fighter Squadron (510 FS), AAB, Italy (Tab U-101). The MA departed AAB at approximately 1900 local (L) on 28 January 2013 (Tab K-3). The Mishap Pilot (MP) wore his anti-exposure suit to protect against hypothermia in case of an over-water ejection and used Night Vision Goggles (NVG) to enhance his night situational awareness (Tab V-2.6, V-4.3, V-5.3, and V-10.2). At 19:49:13 Local (L), the MP transmitted “CLAW knock it off, I’m spatial D,” meaning the MP was experiencing spatial disorientation (Tab N-17). Twelve seconds later, at 19:49:25L, the MP ejected from the MA (Tab DD-9). Immediately after initiation of the ejection sequence, the MP’s helmet came off the MP’s head (Tab DD-163). As a result, the MP suffered severe head and neck trauma, causing his death (X-3). The MA impacted the water shortly thereafter, approximately four miles from the ejection site (Tab S-3). The impact destroyed the MA and its associated property, which was valued at $28,396,157.42 (Tab P-5).

3. BACKGROUND

The MA was assigned to the 510 FS, 31st Fighter Wing (31 FW), Third Air Force (3 AF), United States Air Forces Europe (USAFE), stationed at AAB, Italy (Tabs U-101 and CC-13). The MP was assigned to the 555th Fighter Squadron (555 FS), 31 FW, 3 AF, USAFE, stationed at AAB, Italy (Tabs G-3, and G-7).

a. United States Air Forces in Europe (USAFE)

With headquarters at Ramstein Air Base, Germany, USAFE is a major command of the US Air Force. It is also the air component for two Department of Defense unified combatant commands: the US European Command (EUCOM), which serves as the US component of the North Atlantic Treaty Organization (NATO), and the US Africa Command (AFRICOM), which oversees security cooperation programs that assist African nations in building their own security capacity. Combined, these two theaters cover more than 19 million square miles, contain 105 independent states, and possess more than a quarter of the world's population (Tab CC-3 to CC-6).

b. Third Air Force (3 AF)

Third Air Force is USAFE's component numbered air force for EUCOM and AFRICOM. Based at Ramstein Air Base, Germany, 3 AF directs all USAFE-AFAFRICA forces engaged in contingency and wartime operations in the EUCOM and AFRICOM areas of responsibility. Along with its headquarters operations directorate, the command is comprised of 10 wings, 2 groups, and the 603rd Air and Space Operations Center (Tab CC-7).

c. 31st Fighter Wing (31 FW)

The 31 FW, AAB, Italy, delivers combat power and support across the globe to achieve US and NATO objectives. The 31 FW maintains two F-16CM fighter squadrons, the 510 FW and the 555 FW, capable of conducting offensive and defensive air combat operations. The 31 FW prepares for its combat role by maintaining aircraft and personnel in a high state of readiness (Tab CC-9).

d. 31st Operations Group (31 OG)

The 31 OG ensures the combat readiness of two F-16CM squadrons, one air control squadron, and one operational support squadron conducting and supporting worldwide air operations. The group prepares fighter pilots, controllers, and support personnel to execute U.S. and NATO war plans and contingency operations. It trains, equips, plans, and provides weather, intelligence, standardization/evaluation, and command and control sustaining global flying operations (Tab CC-11).

e. 510th Fighter Squadron (510 FS)

The 510 FS provides combat power on demand to US and NATO combatant commanders as well as the National Command Authority in order to meet national security objectives. The unit performs air and space control and force application roles of counterair, strategic attack, and counterland including interdiction and close-air support with 21 F-16CMs employing state-of-the-art munitions in support of joint, NATO, and combined operations (Tab CC-13).

f. 555th Fighter Squadron (555 FS)

The 555 FS provides combat airpower on demand to US and NATO Combatant Commanders as well as the National Command Authority in order to meet national security objectives. It also performs air and space control and force application roles of counterair, strategic attack and counterland, including interdiction and close-air support with 21 F-16CMs employing state-of-the-art munitions in support of joint, NATO, and combined operations (Tab CC-15).

g. F-16 Fighting Falcon

The F-16 Fighting Falcon is a compact, multi-role fighter aircraft. It is highly maneuverable and has proven itself in air-to-air combat and air-to-surface attack. It provides a relatively low-cost, high-performance weapon system for the US and allied nations (Tab CC-17).

4. SEQUENCE OF EVENTS

a. Mission

The mishap flight (MF), consisting of three F-16CMs and one F-16DM, was designated as CLAW 21 and was scheduled for 28 January 2013. The MF included CLAW 21, 22, 23, 24, (with a flight surgeon in the backseat of CLAW 23). As part of a night flight lead upgrade (FLUG) for CLAW 21, the mission scheduled was a night 4V2 opposed surface attack tactics (OPSAT) training mission (Tab V-6.2). The MF's 4V2 mission was to act as four friendly aircraft attacking enemy ground targets. Two enemy aircraft, simulated by VENOM flight, were to protect those targets (Tab V-1.3, 6.2 and 7.2). CLAW 21 was the Mishap Aircraft (MA)/Mishap Pilot (MP) (Tab K-3). The MP was a current and qualified F-16CM day-only flight lead and was acting as the flight lead of CLAW flight as part of his night FLUG training (Tabs G-3 and G-120). CLAW 22 was the Mishap Wingman (MW); he was also the Instructor Pilot (IP) of record for the flight (Tab V-1.2). The MW was a current and qualified F-16CM IP, a Weapons Instructor Course (WIC) graduate, and was acting as the IP of the flight responsible for its overall conduct (Tabs G-30 and K-3). CLAW 23 was the deputy flight lead in the F-16DM. CLAW 24 was CLAW 23's wingman (Tab K-3). The planned mission tasks included takeoff, navigation to the airspace, air-to-air engagement with VENOM, surface attacks against ground targets, and threat reactions against simulated surface-to-air missiles (SAMs) (Tab BB-46). The mission was to culminate in a return to AAB (Tabs V-1.6 and V-6.4). The sortie was authorized by the 510 FS TOP 3 (squadron operations supervisor in charge of daily flying ops) and was scheduled IAW 31 OG Syllabus (Tabs K-16 to K-18).

b. Planning

On 28 January 2013, the MP was assigned to the 555 FS. The 555 FS was off-station due to training, so the MP was flying with the 510 FS (Tab V-6.5). The MP planned and briefed the mission IAW AFI 11-2F-16, *F-16--Operations Procedures*, Volume 3 (Tab V-1.4). The 510 FS TOP 3 briefed the MF and VENOM flight in a mass briefing on the expected weather. The 510 FS TOP 3 approved the Flight Operational Risk Management (ORM) IAW 510 FS ORM matrix (Tab K-19, V-4.2, and V-4.3). ORM is a decision-making process to identify risks and benefits and to determine the best course of action for any given situation (Tab BB-58). After the mass brief, the MP conducted an adversary coordination brief with VENOM flight. This detailed brief covered separation of aircraft, the specifics of air-to-air engagements expected between MF and VENOM flights, and a discussion of the expected weather (Tab V-1.3, V-1.4, and V-6.2). Thereafter, the MP briefed the MF on the upcoming mission, covering all the required briefing areas including, flight administration, air-to-air and air-to-ground tactics, and night considerations (Tab V-1.3). The MW, the IP of record, considered the MP's brief standard (Tab V-1.3).

c. Preflight

The 510 FS TOP 3 briefed the MF on updated weather, Notices to Airmen (NOTAMs), aircraft configuration, maintenance records of individual aircraft from prior flights, and aircraft parking spot locations (Tabs V-4.2 and V-4.3). The MP was wearing all the required items for the flight over water, as observed by his flight members and the 510 FS TOP 3 (Tabs V-4.3 and V-8.4). The preflight, strapping into the jet, and engine start were uneventful (Tab V-8.4).

d. Summary of Accident

The MF's start, taxi, and takeoff were uneventful (Tab V-8.4 to V-8.5). At 1903 Local (L), the MF departed to their over water scheduled airspace areas named SARA and SPEEDY, utilizing the standard AAB flight plan procedures (Tabs K-3 and S-2). The Padova Airspace Control agency approved the MF flight into SARA and SPEEDY airspace at 1913L (Tab N-3). The MF entered the airspace and conducted a gravitational force (G)-awareness exercise at 1916L (Tab N-4). This maneuver consists of two 90-degree turns involving 4 to 5 Gs. It is used to check equipment and to assess each pilot's G tolerance. After the G-exercise, the flight continued to the SPEEDY part of the airspace located to the east (Tabs N-4 and N-7). For the next 15 minutes, the MP tried to find workable airspace and weather required for air-to-air training. Not finding the weather suitable and in conjunction with CLAW 23, the MP made the decision to let VENOM flight return to base (RTB) (Tab N-8). The MP initially made the decision for the MF to burn down gas and then to RTB. However, after finding workable airspace, at 1933L the MP made the decision to split up the MF four-ship into two separate two-ship flights to conduct unopposed bombs on coordinates (BOC) attacks. To ensure adequate altitude separation between the two flights, the MP assigned MP/MW the 20,000 to 24,000 foot block and assigned CLAW 23/24 the 15,000 to 19,000 foot block of altitude (Tab N-8).

At 1934L, the MP directed the other element, consisting of CLAW 23 and 24, to a separate secondary frequency. Thereafter, MP/MW operated as a two-ship. The MP and MW conducted simulated BOC attacks on preplanned target points (Tabs N-9, and S-2). After completing two attacks, at 1947L, the MP communicated to the MW a simulated threat targeting MW's aircraft. The MW executed a threat reaction against a simulated SAM, which included a "last ditch" maneuver. In a "last ditch" maneuver, the pilot attempts to defeat the threat by visually acquiring the incoming SAM while maneuvering the aircraft aggressively nose up or down with altitude changes (Tab DD-69). The MW completed the threat reaction at 19:47:40L (Tabs N-16 and N-17).

Twenty-eight seconds later at 19:48:08L, the MP initiated his threat reaction against a simulated SAM threat. The maneuvering initially consisted of a series of two to three G turns at approximately 90 degrees of bank descending between 23,000 and 21,000 feet (Tab DD-8). During the maneuvering, the MA autopilot, which was engaged prior to the initiation of the threat reaction, failed and disengaged (Tab J-5). The autopilot disengaged due to the MA exceeding angle of attack limits (Tab J-5). The summary of recorded data source (SRD) indicates that at 19:48:35L the MA exceeded 15 degrees angle of attack (Tabs J-6 and DD-5). This action caused the autopilot to fail and disengage and produced a pilot fault message "FLCS A/P FAIL," and seven seconds later would have produced an aural "CAUTION, CAUTION" warning (Tabs J-5 and J-6). FLCS A/P stands for "Flight Control System Auto Pilot." This message meant the autopilot was no longer operative (Tab J-5).

The AIB simulated the last twenty-six seconds of the flight, including the "last ditch" maneuver (Tab DD-11). As part of that simulation, the AIB members set the Precision Ground Collision Avoidance System (PGCAS) value as low as 125 feet. The AIB members consistently received "break X" indications, including a pull up aural warning and accompanying symbology that require the pilot to recover the aircraft (Tab DD-11).

At 19:48:57L, as part of the threat reaction, the MW called out a simulated visual pick up of the SAM, still guiding on the MA at the MP's right three o'clock position. The MW specifically stated, "CLAW 1 [MP] missiles your right 3 o'clock, 6 miles." At 19:49:03L, the MP replied, "CLAW 1 [MP] last ditch (Tab N-17)." This communication implied that MP was now executing a "last ditch" maneuver to defeat the simulated SAM. Just prior to this communication at 19:49:01L, the MP rolled the MA inverted to the right and pulled the nose down. The MA continued the roll to the right, initially stabilizing in approximately 150 degrees left bank and 40 degrees nose low. For the next ten seconds, the MA maintained nose low attitude as the dive angle increased to 45 degrees nose low, while the MA continued the roll to the right and stabilized with approximately 90 degrees left bank. The MA also accelerated through 400 knots as the altitude decreased to 17,700 feet (Tab DD-8). At 19:49:10L (Figure 1), the MW transmitted "CLAW 1 [MP] missile overshot," indicating that the simulated missile was no longer a factor and that the threat reaction was successful. Three seconds later at 19:49:13L, the MP transmitted "CLAW knock it off, I'm spatial D" (Tab N-17).

(**A visual depiction of the entire MA sequence follows in Figures 1, and 3-6, below. Each depiction shows the visual depiction of the aircraft and a representation of aircraft flight parameters, i.e., g-loading, airspeed, attitude, altitude, and vertical velocity. Figures 1, and 3-6 are derived from Lockheed Martin data analysis (Tab DD-5). Note: Time slices in Local time are 16 seconds fast due to Coordinated Universal Time (UTC) to Global Positioning System (GPS) time difference (Tab DD-5)). In the Figures, local time is indicated in the white box.)

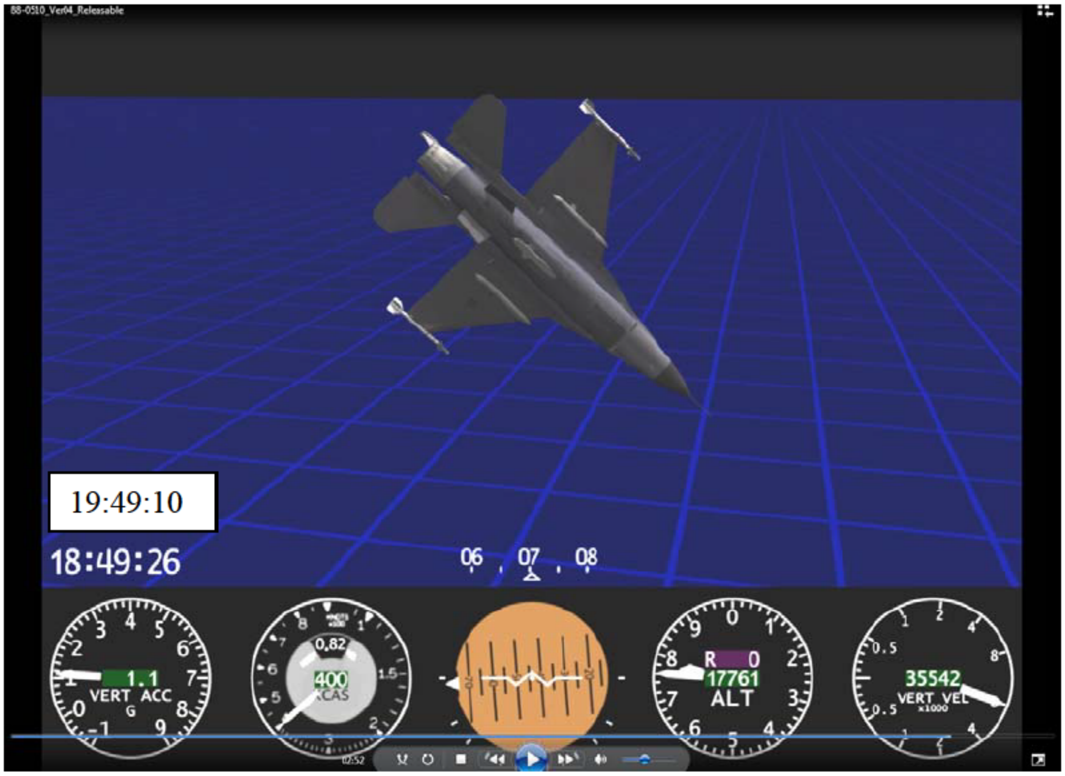


Figure 1 (Tab Z-4)

"Knock it off" procedures are used to direct aircraft or aircrew to stop engagements, scenarios and tactical maneuvering. "I'm spatial D" meant that the MP recognized that he was spatially disoriented. Spatial disorientation is a failure to correctly sense a position, motion, or attitude of the aircraft or of oneself within the fixed coordinate system provided by the surface of the earth and the gravitational vertical (Tab BB-32). Three seconds later at 19:49:16L, the MW directed the MP to transition to primary recovery instruments by communicating "Look at the round dials, disregard the HUD" (Tab N-17). The round dials are the primary attitude, altitude, and airspeed indicators used in unusual attitude recovery, and the HUD is the head-up display (Figure 2 and Tab BB-55).

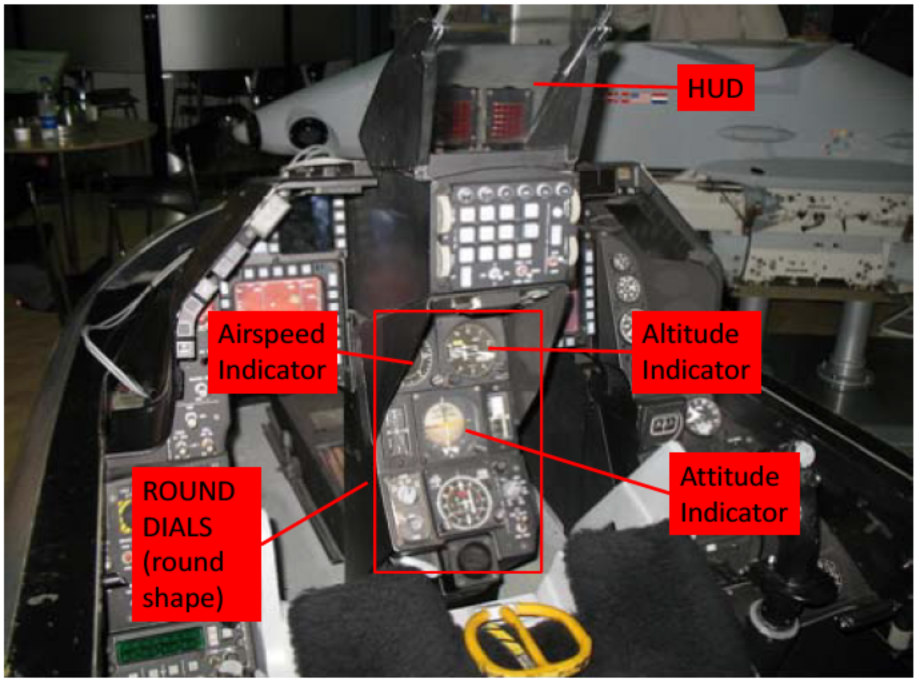


Figure 2

"Round Dials" (Tab Z-3)

The MA initially continued with the same flight parameters. Then one second later, at 19:49:17L, the MP rolled the MA left, away from the horizon to approximately 180 degrees fully inverted, with the top of the canopy pointing directly towards the ground, and pulled to 70 degrees nose low, towards the water. The MA airspeed increased to 535 knots, as the MA passed through 12,000 feet of altitude. One second later, at 19:49:18L (Figure 3), the MP initiated a rapid roll to the right, attempting to establish wings level flight.

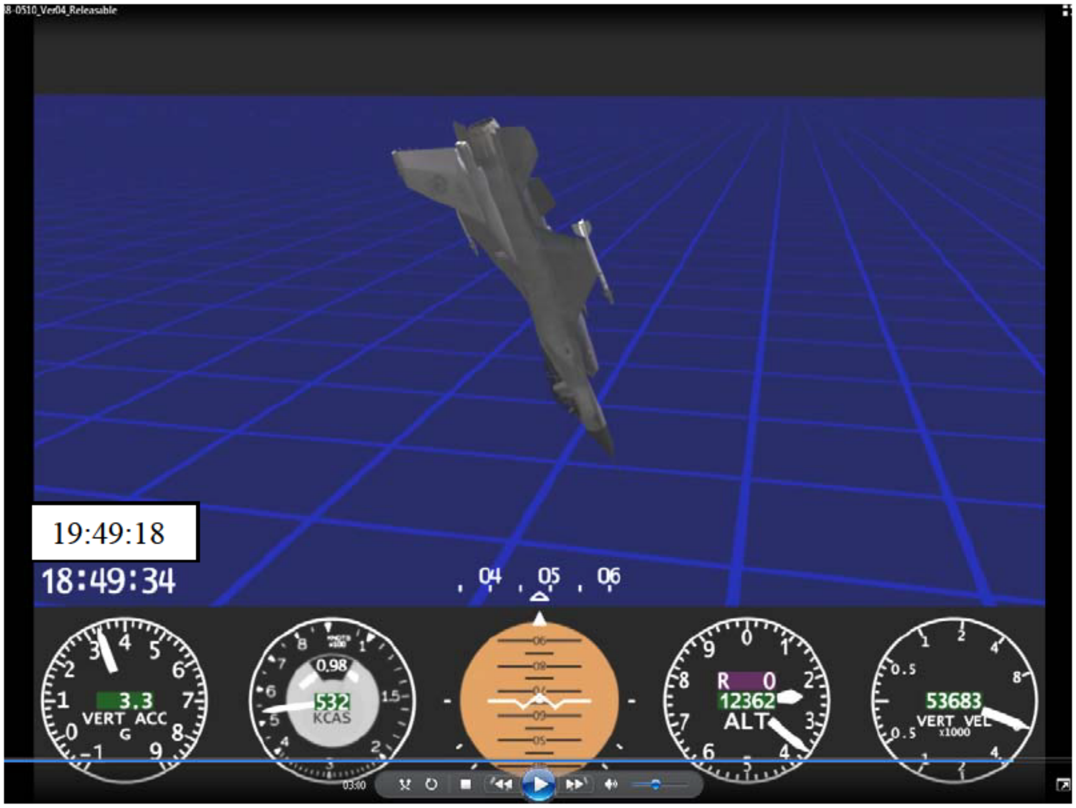


Figure 3 (Tab Z-5)

By 19:49:20L (Figure 4), at 10,000 feet, with a descent rate of 57,500 feet per minute, the MP established the MA at 55 degrees nose low in approximately upright wings level flight. At the same time, the MA's gravitational force loading increased from 2.0 Gs to a maximum recorded 8.6 Gs as the MA nose started to come up towards the horizon from 55 degrees nose low (Tab DD-9).

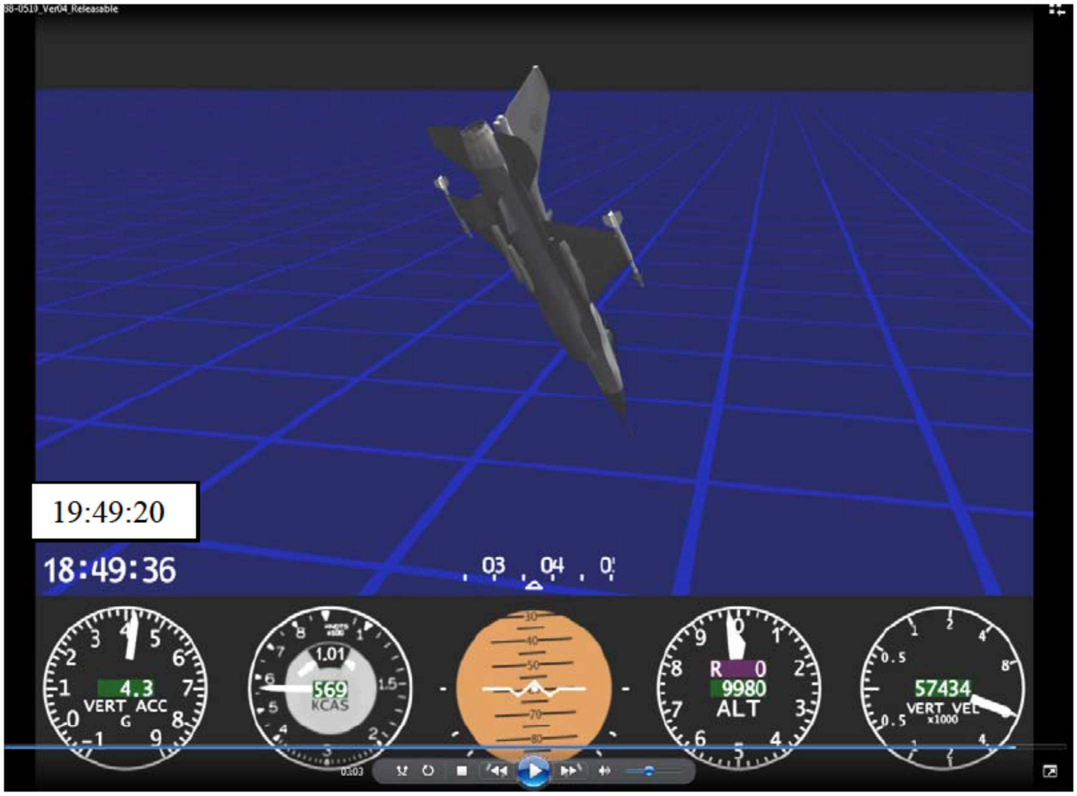


Figure 4 (Tab Z-5)

At 19:49:23L (Figure 5), the MW queried the MP: "1 status your round dials?" with no response from the MP (Tab N-17). This question implies the MW was trying to determine if the MP had transitioned his scan to the primary attitude instrument. At this time, the MA was at 25 degrees nose low, 15 degrees left bank, 568 knots, 8.6 Gs, while passing through 7,900 feet with a descent rate of 37,300 feet per minute (Tab DD-9).

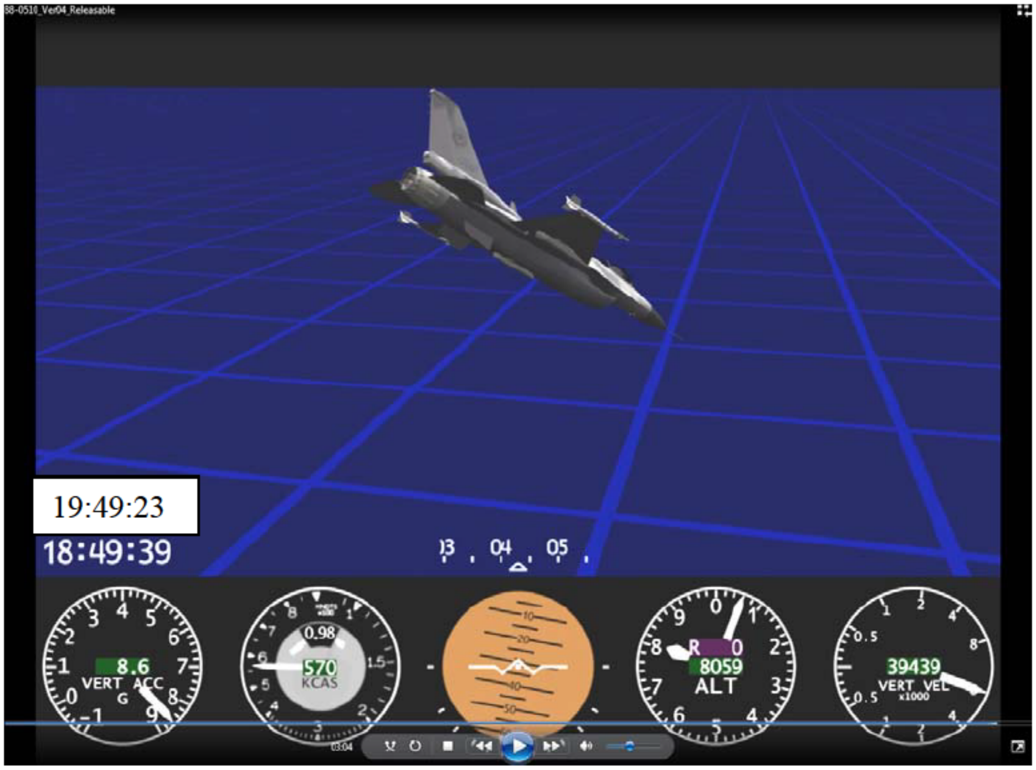


Figure 5 (Tab Z-6)

Simultaneously, the MA SRD recorded an air data miscompare, which resulted in an Air Data Fail maintenance fault list (MFL) (Tab J-5). There is not enough resolution in the data to determine why an air data miscompare occurred. Lockheed Martin analysts suspect there may have been sufficient sideslip during the final maneuver that caused a side mount impact pressure or static pressure miscompare from the nose mounted impact and/or static pressure inputs. The Air Data Fail MFL would have generated a FLCS ADC (Air Data Computer) FAIL PFL (pilot fault list) (Tab J-5). FLCS ADC FAIL PFL means that data from one of the three air data sources on the aircraft does not agree with the others. Based on a review of Technical Order (TO) 1F-16CM-1, *Flight Manual*, FLCS ADC FAIL PFL would produce no noticeable degradation of aircraft performance (Tab DD-69).

At 19:49:24L, the G forces on the MA started to decrease rapidly, indicating the MP was no longer pulling back on the control stick. The MP then initiated the ejection sequence. At 19:49:25L (Figure 6), the seat data recorder stopped receiving input from the MA, indicating the seat had begun to depart the MA.

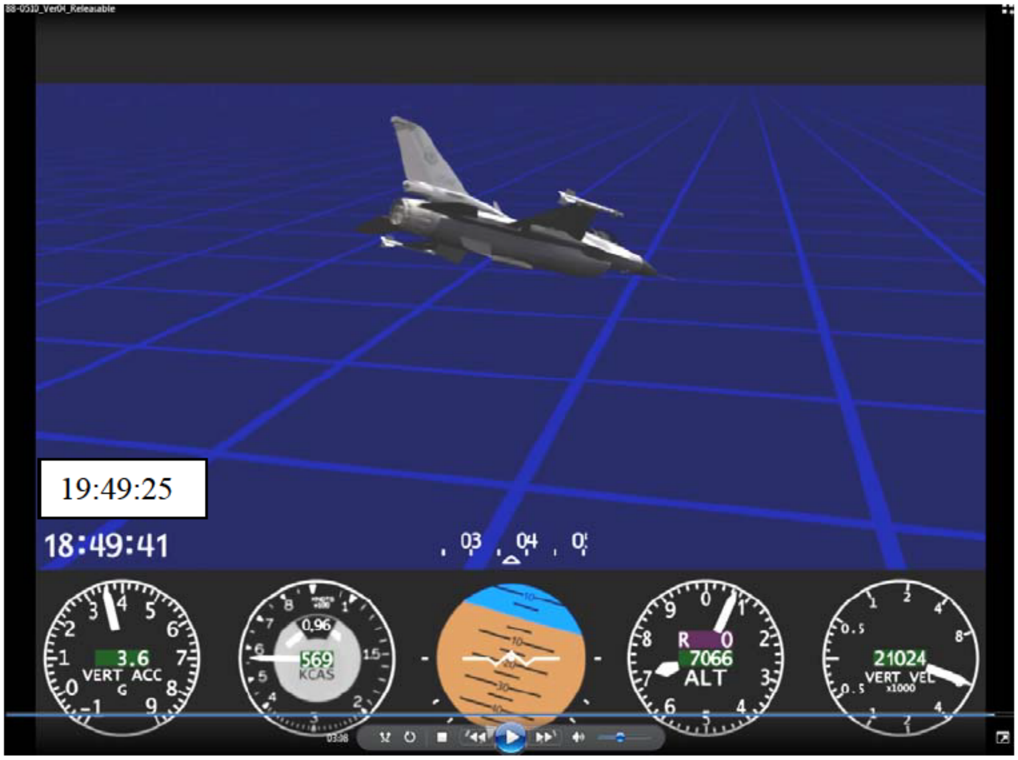


Figure 6 (Tab Z-6)

The MA parameters at the time of the ejection were a heading of 037 degrees, 7,066 feet altitude, 569 knots (.96 Mach), dive angle of 16 degrees nose low, and 18 degrees left bank and with a 21,024 feet per minute rate of descent (Tab DD-9). The ejection occurred at approximately N 44 17.786 E 12 35.239 (Tab S-2).

The MP encountered pure windblast forces of 569 knots (.96 Mach) upon ejection (Tab DD-9). TO 1F-16CM-1, Flight Manual, stipulates that ejecting at speeds over 400 knots exposes the pilot to severe forces (Tab BB-51). The MP ejected closer to 600 knots where extreme windblast forces are expected to be encountered (Tabs BB-51 and DD-9). The MP suffered severe head and neck injuries, a compound fracture of the left lower leg and a right elbow dislocation during the ejection (Tab X-3).

Data shows that the ejection seat departed the MA with left yaw (Tab DD-52). Lockheed analysis of the mishap sequence indicates possible side slip of the aircraft just prior to ejection (Tab J-5). The MA yaw set up a subsequent left turning acceleration in the ejection seat, which eventually led to a violent 40+ G snapback when the drogue chute deployed during the ejection seat sequence (Tab DD-52). The 40+ G right lateral snapback would have imparted excessive loads to the unrestrained head and neck. (See, *Injury Criteria and Human Tolerance for the Neck*, Channing L. Ewing, Aircraft Crashworthiness, University Press of Virginia, Charlottesville, 1975.)

e. Impact

The MA impacted the water at approximately 1949L on 28 January 2013 in the vicinity of N 44 21 E 012 39. The impact location was in the Adriatic Sea, approximately seven miles northeast of Cervia, Italy (Tab J-2 and Tab S-2 to S-3). The MA was configured with two Air Intercept Missile (AIM)-120 captive trainer missiles, an AIM-9 captive trainer missile, a USAFE Rangeless Interim Training System data recording pod, two wing tanks, an Electronic Countermeasures (ECM) pod, and a Sniper targeting pod (Tab J-2). The last known data for the MA parameters showed a heading of 037 degrees, 16 degrees nose low, in an 18 degrees left bank at 7,066 feet and 569 knots (.96 Mach) (Tab H-12). The MA was destroyed upon impact (Tab CC-19). The center of the debris field was located approximately 4 miles from the ejection site on a heading of 043 degrees (Tab S-3).

f. Egress and Aircrew Flight Equipment (AFE)

At ejection, the MA was 16 degrees nose low in an 18 degree left bank under 3.6 G and 569 knots (.96 Mach) (Tab DD-9). The MP initiated ejection within the performance envelope, that is, the acceptable range of speed, attitude, and altitude, of the Advanced Concept Ejection Seat II (ACES II) ejection system (Tab H-12). However, TO 1F-16CM-1, *Flight Manual*, adds a warning to the ejection section that states that for ejections within these design parameters of the ejection seat, windblast will exert severe forces, causing flailing and skin injuries between 400-600 knots (Tab BB-51). The MP was wearing a Helmet Mounted Cueing System (HMCS) helmet with ANVIS-4949 night vision goggles at the time of the ejection (Tab DD-157, DD-133 and DD-138.). Based on a review of TO 1F-16CM-1, *Flight Manual*, along with the flight data from the MF, it is reasonable to expect the HMCS helmet would fail and that this would result in potentially fatal loads on the mishap pilot's neck (Tab DD-69).

The canopy separated immediately after the MP initiated the ejection sequence. The ejection seat retraction reels retracted but did not retract to equal lengths. The left side strap protruded 3 inches from the back of the seat to the tip of the fitting while the right strap protruded 4.5 inches, indicating a greater tension on the right strap (Tabs Z-4 and DD-161) This indicates the MP's position in the seat at the time was off center, to the left (Tab DD-161). As the ejection seat rocket motors fired, the MP experienced an approximately 15 G downward force (Tab DD-49). The MP's helmet came off the MP's head during the initial windblast (Tab DD-163). The ejection seat departed the MA in a left yaw, with 10 Gs of left lateral force (Tab DD-50). The ejection seat continued to yaw further to the left during the remainder of the ejection sequence (Tab DD-50). At the deployment of the drogue chute, which is designed to stabilize the seat for ejections above 250 knots, the MP experienced at least a 40 G lateral snapback to the right (Tabs H-3 and DD-50).

The MP should have experienced a Mode 3 ejection based on the last recorded MA data (Tab H-3). The seat recorded that the MP actually experienced a Mode 2 ejection (Tabs DD-42 and DD-44). In this case, the seat selected the correct ejection mode since all three data sensors agreed on a Mode 2 ejection (Tabs DD-42 and DD-44). The difference between the two ejection modes is that during the Mode 3 ejection, the DRS deploys the drogue chute and then waits until the seat is within the altitude and airspeed limits of the Mode 2 ejection. After those parameters are reached, the seat then functions just like the Mode 2 ejection. This is immediately followed by man-seat separation and deployment of the main parachute. (Tab H-3). The ejection sequence, parachute deployment, and seat separation functioned as designed (Tabs H-3, H-11, and DD-42).

A thorough review of the AFE inspection and maintenance records revealed several discrepancies. There is no evidence to suggest these discrepancies were a factor in the mishap or the MP's death. The Flight Equipment Records Management System (FERMS) did not reflect compliance with the 120-day G-suit fit check. Additionally, the Time Compliance Technical Order (TCTO) for the onetime G-suit inspection for the water check valve was marked correctly on the G-suit, but not annotated in FERMS (Tabs U-118 and Z-8). The personnel locator beacon (PLB) "battery well" TCTO was complied with in the Integrated Maintenance Data System (IMDS), but not annotated in FERMS (Tab U-117 and U-119).

The Search and Rescue (SAR) recovered all of the MP's equipment except for the parachute assembly, Universal Water Activated Release System (UWARS), night vision goggles, and the NVG bracket (Tabs H-12, DD-157, and DD-158). The helmet was recovered on 30 January 2013 (Tab V-12.3, V-12.4, and V-12.6). The inspection on the helmet was current (Tab U-121). There is no evidence of witness marks on the helmet that would be consistent with the helmet striking the headrest during ejection (Tab DD-159). A witness mark is evidence of two physical objects making contact with each other. This suggests the helmet came off the MP's head during initial windblast as the canopy departed the MA (Tab DD-163). The lack of witness marks on the mask's right bayonet and the helmet edge roll indicates the mask was not connected on the right side at the time of ejection (Tabs DD-159). The helmet also had witness marks on the bottom of the edge roll consistent with the helmet rotating back prior to coming off the MP's head (Tab DD-159).

The MP only had one G-suit assigned for flying operations. After the recovery of the MP and the life support equipment, inspection of the G-suit revealed the comfort zippers on the G-suit were not zipped up (Tab DD-61).

The ACES II Ejection Seat contains a PLB intended to transmit emergency notification and location information via line-of-sight Ultra High Frequency (UHF), Very High Frequency (VHF), and beyond-line-of-sight satellite frequencies. The PLB has automatic and manual modes. The Radio Beacon Selector switch controls PLB mode selection and is located through a cutout in the front of the seat pan. The switch is a rocker switch with two settings, MAN and AUTO. With MAN selected, the radio beacon will not activate at man-seat separation (Tab DD-181). With AUTO selected, the radio beacon activates at man-seat separation (Tab DD-67). The PLB from the MA seat did not function as designed. The MP's PLB did not alert any local aircraft or radar stations via the emergency guard frequencies of 243.0 and 121.5 (Tab N-26). The recovered MA ejection seat showed the PLB selector switch was set to AUTO (Figure 7, Tab DD-67).

Figure 7 (Tab DD-181, text added by AIB)

The plunger switch on the survival kit container, which activates the PLB at man-seat separation, was ripped off the bracket and the wires that attached it to the kit (Tab DD-181 and DD-182). The bracket on the seat pan lid that pushes the plunger switch down when the lid is closed may have caused the PLB damage (Tabs DD-161, DD-185, and DD-186).

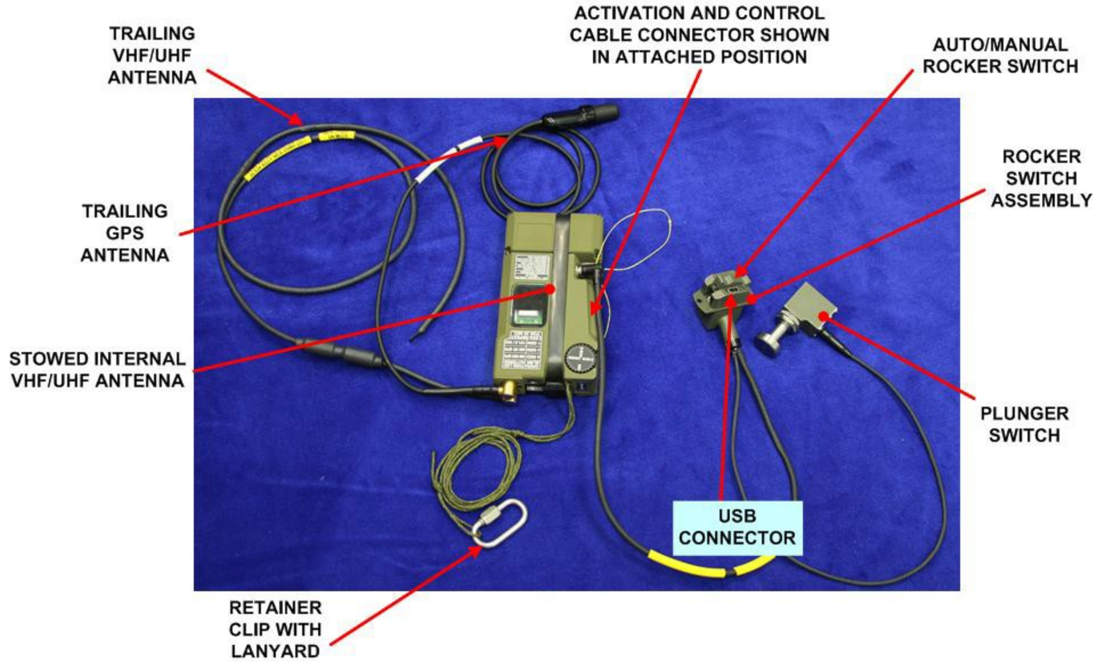


Figure 8 (TAB Z-7)

Activation and Control Cable Attached to PLB

After man-seat separation, the life raft inflated as the survival kit deployed. None of the components in the survival kit were used (Tabs V-12.6, DD-157, and DD-158).

At some point in the ejection process, the adjustment lacing at the collar of the life preserver unit (LPU) separated from the harness. The LPU inflated upon contact with the water (Tab DD-163).

The MP's LPU was behind his head at the time of recovery. The cause of this was that the LPU adjustment straps were not routed over the harness chest strap (Tab DD-65; Tab Z-12 depicts appropriately routed LPU straps). The routing of the LPU straps would put the MP in an unfavorable body position (Tab DD-61). A review of the AFE lesson plan was conducted; it did not cover the proper routing of LPU adjustment straps (Tab DD-153).

The MP's survival vest sustained minor damage during the ejection. Stitching on three of the pocket rails were broken, but the pockets were still fully attached on the vest (Tab Z-2). There is no evidence to suggest the MP attempted to access or utilize the survival radio (Tab Z-2).

Figure 9

Broken stitches on MP's survival vest pockets (Tab Z-2)

Figure 10

Broken stitches on MP's survival vest pockets (Tab Z-2)

According to AFI 11-301, United States Air Forces in Europe Supplement, Volume 1, para 7.5.3., the wear of an anti-exposure suit is mandatory for sorties over water that has a temperature of 60 degrees F and below. The MP was wearing the approved Over-the-Side (OTS) anti-exposure suit. Inspection of the OTS after recovery revealed the relief port zipper on the suit was unzipped 2-3 inches (Tab DD-61). The MP wore a t-shirt, underwear and cotton socks under the OTS suit (Tab DD-61). Based upon these factors, estimated survival time for the MP would have been 2.5 hours if his OTS suit had been zipped closed (DD-72).

g. Search and Rescue (SAR)

After a "knock it off" call from the MW at 1949L informing CLAW 23 and 24 that something unusual had occurred, the MW initiated SAR for the MP (Tab N-11 to N-13 and Tab DD-69). The MW directed CLAW 23 to contact the Supervisor of Flying (SOF) and let the SOF know that contact with MA had been lost. CLAW 23 contacted the SOF at 1953L and passed along the information that the MW had lost contact with the MP and the MA position indicator was no longer displayed on the data link (Tab N-12). The MW requested clearance from Padova Airspace Control to descend below the airspace. The MW was also working through the abnormal procedures (pink) pages of the in-flight guide (Tab N-13). The pink pages contain the checklist of steps to follow as the initial on-scene commander of the SAR effort (Tab BB-44). At 1955L, the SOF informed the AAB tower crew that the MW declared an emergency due to losing contact with the MP and that no emergency locator transmitter (ELT) had been heard by any of the aircraft airborne (Tab N-26). ELT is another name for PLB. At 1956L, CLAW 23 passed the SOF the following coordinates as the last known location of the MA: North 44 13.88 East 12 27.37 (Tab N-14). AAB Tower notified the Command Post (CP) at 2006L of the overdue aircraft, which was the MA (Tab N-19). At 2024L, Radar Approach Control (RAPCON) notified CP that Padova Airspace Control had activated SAR. Padova Airspace Control also informed RAPCON that SAR was initiated at 1958L (Tabs N-19 and N-28). The actual notification from Padova Airspace Control to the Italian Air Force (ITAF) SAR occurred at 1955L (Tab DD-17).

The ITAF and Coast Guard provide SAR capabilities to the 31 FW. The 31 FW does not have integral SAR assets and will not fly if the Italian SAR assets are unavailable (Tab V-12.3). The Italian authorities also will not authorize US flights if the SAR assets are not available (Tab V-12.3). The initial SAR assets consisted of five boats and a helicopter. The Cervia Air Base ITAF helicopter was airborne at 2130L that night and was on station searching from 2140L to 2215L (Tab DD-17). The helicopter returned to base at 2225L due to deteriorating weather conditions. At that time, the weather was fog and overcast clouds at 1,000 feet (Tab DD-17). On 29 January 2013 at 0015L, a US Navy P-3 aircraft augmented SAR assets. Additionally at 0300L, three merchant ships joined the SAR effort (Tab N-20). On 29 January 2013, the ITAF helicopter conducted two SAR sorties starting at 1140L and ending at 1615L (Tab DD-17). The observed weather on 29 January 2013 was visibility of approximately 3,000 feet, slightly improving towards the evening (Tab DD-17).

On 30 January 2013, the 31 FW sent a liaison team to the Ravenna Coast Guard Station to assist in the SAR effort. The Ravenna Station had the overall responsibility for the SAR. According to the US liaison, the Italian personnel were doing their best with everything they had to find the MP (Tab V-12.5). Throughout the SAR effort, the weather hampered the search with low cloud ceilings, rain, fog, and limited visibility of about one mile (Tabs V-11.6 and V-12.4). The MP's helmet was recovered on 30 January 13 (Tabs V-12.3 through V-12.6). The search continued, and by 31 January 2013 it consisted of: Italian Coast Guard and civilian vessels, an ITAF helicopter (on station 1230L-1450L), a US Navy P-3 airplane, a US Air Force C-130, and US Air Force F-16s. The Italian Coast Guard recovered the MP's remains on 31 January 2013 at approximately 1500L (Tabs N-20, V-12.6 and DD-17).

h. Recovery of Remains

The 31st Force Support Squadron (31 FSS) Mortuary Team assembled at AAB Italy on 31 January 2013 at 0900L. The team consisted of approximately 50-60 US personnel and left the base at 1115L in two buses. The team leader was the 31 FSS commander. At approximately 1500L on 31 January 2013, about one hour prior to the team reaching the original destination, they received the news that the Italian Coast Guard recovered the remains of the MP. Thereafter, one of the buses turned back to return to AAB as those personnel were no longer required for the search effort. The lead bus with a Mortuary Affairs trained officer on board continued towards the original destination. At 1830L, the Mortuary Officer positively identified the MP's remains at the Italian morgue. The same officer and a 31 FW Security Forces member then stayed overnight in the town near the morgue to ensure US presence nearby (Tab V-11.2 to V-11.8).

The next day, a four-person 31 FSS team arrived to maintain 24-hour daily watch over the remains until the US took custody of the MP's body on 7 February 2013 (Tab DD-22). Prior to the release to US custody, the Italian authorities conducted an autopsy, with the US Safety Investigation Board Flight Surgeon present during the procedure. From 7 February to 8 February 2013, the MP's remains were located at the Prosdocimo Funeral home near AAB. The dignified transfer of the remains back to the Continental US occurred on 8 February 2013 on a USAF C-17 aircraft (Tabs V-11.4 to V-11.8, and DD-22).

5. MAINTENANCE

a. Forms Documentation

(1) Summary

The total airframe operating time prior to the time of the mishap was 7,354.1 hours (Tab D-2). The Mishap Engine (ME) was a F110-GE-100 engine serial number (S/N) GE0E509145 and was installed into the MA on 29 March 2012. It had 8,166.7 hours total engine operating time with 2,769 hours Engine-Flight Time (EFT) (Tabs D-2 and D-16 to D17).

A detailed review of active and historical Air Force Technical Order (AFTO) Form 781 series aircraft maintenance forms, AFTO Form 95 series historical data forms, and Jet Engine Intermediate Maintenance historical data revealed no discrepancies indicating engine, mechanical, or flight control anomalies existed on the MA (Tab D-4 to D-34). A thorough review of the active AFTO 781 forms and AFTO 781 historical records for the time period 90 days prior to the mishap revealed no evidence of mechanical, structural, or electrical failure. 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-3 to U-99). None of the open Time Compliance Technical Orders (TCTO) in the active forms restricted the MA from flying; a review of the historical records showed all TCTOs had been accomplished IAW applicable guidance (Tabs D-19 and D-35). There is no evidence that compliance with AFTOs, TCTOs, or maintenance historical records, was a factor in the mishap.

The MA flew a total of 14 sorties in the 90 days prior to the mishap. Seven of those flights were classified as Code 1 (no significant maintenance problems noted), three were Code 2 (aircraft has some degraded performance, but is still flyable), and four were Code 3 (significant problems that require repair before the aircraft can fly again). The MA's Code 3 discrepancies are identified below (Tab U-101 to U-102):

> 3 December 2012 – Door between hook and left ventral opened in flight. Maintenance adjusted door 4301 latch to hold properly.
>
> 15 January 2013 – Flight Control System (FLCS) Single Fail 055 Maintenance Fault Light (MFL). Maintenance removed and replaced the Digital Flight Computer (DFLC).
>
> 22 January 2013 – Fire Control Radar (FCR) unusable with multiple MFLs. Maintenance removed and replaced modular low-power radio frequency.
>
> 23 January 2013 – FLCS single fail Pilot Fault Light (PFL) with FLCS 045 and 049 MFLs upon landing. Maintenance removed and replaced the weight-on-wheels switch.

There is no evidence to suggest the in-flight discrepancies were a factor in the mishap.

(2) Major Maintenance

The only major maintenance performed on the MA in the 30 days preceding the mishap was on 9 January 2013. The engine was partially removed to replace an augmenter fuel pump that was leaking out of limits. The pump was replaced and the engine was reinstalled and tested with no incident. There is no evidence to suggest this maintenance was a factor in the mishap (Tab U-9 to U-19).

(3) Recurring Maintenance Problems

Maintenance records indicated no recurring problems with the MA, besides the Code 3 discrepancies with the FLCS listed above. A review of the MA AFTO 781 Forms and IMDS data also revealed no further recurring problems (Tabs D-5 to D-12, and U-3 to U-99).

(4) Open Write-ups

The MA AFTO Form 781A had two non-grounding open write-ups at the time of the mishap (Tabs D-5 to D-12). These open write-ups were minor discrepancies that had not yet been corrected. The discrepancies did not affect the airworthiness of the MA. The non-grounding open write-ups were: (1) ARC-210 no transmit or receive on VHF secure, no transmit or receive on UHF airborne or on ground; (2) Aircraft requires new transparency per aircrew request for haziness (Tabs D-5 to D-12). The pilot who flew the MA on the night sortie prior to the mishap noted the canopy was suitably clear for flight operations (Tab V-13.1). There is no evidence that any of the open discrepancies had any bearing on the mishap.

(5) AFTO 781K Write-ups

Investigation of the MA AFTO 781K revealed an overdue inspection on the right wing 370-gallon fuel tank and pylon (Tab D-17). The inspection was missed due to inspection tracking issues (Tab DD-151). There is no evidence that any of the open discrepancies had any bearing on the mishap. All other inspections listed on the AFTO 781K were current (Tab D-17).

(6) Pre-flight Operational Checks

The MA AFTO Forms 781A for the period 25-28 January 2013 indicate all pre-flight servicing checks were completed prior to the flight on 28 January 2013. Liquid Oxygen (LOX) was serviced, tire pressure checks were completed, nitrogen servicing was checked, intake inspection was completed, and the MA was fueled to 12,100 pounds (Tabs D-5 to D-12, and D-15).

b. Inspections

(1) Mishap Aircraft

Phase inspections are regularly scheduled maintenance inspections performed on Air Force aircraft at specific flying hour intervals. The last phase inspection accomplished on the MA was completed on 16 December 2011 at 7,198.5 airframe hours (Tab D-2). The aircraft had approximately 244.4 hours remaining before its next phase inspection was due (Tabs D-2 and D-17).

On 28 January 2013, maintenance personnel performed a preflight (PR) inspection on the MA. This type of inspection is valid for 72 hours and was still valid when the MA took off. Additionally, with the weather cancellation of the first two sorties of the day, the MA PR was refreshed before taking off with an intake inspection and tire pressure checks (Tab D-12).

A Production Supervisor signed the Exceptional Release (ER) to release the aircraft from maintenance to operations or the pilot (Tabs D-12, D-14). The ER serves as a certification that the active forms were reviewed and ensures the aircraft is safe for flight (Tab BB-48).

The End of Runway (EOR) crew were the last maintenance technicians to look at the aircraft prior to takeoff. The EOR crew's job was to unpin any munitions loaded on the aircraft and check for any obvious discrepancies such as open doors and panels or incorrect hydraulic systems pressure. EOR crew members did not note anything abnormal about the MA (Tab U-108 and U-110).

(2) Mishap Engine

The most recent inspection accomplished on the ME was the acceptance inspection on 30 November 2011. The ME accumulated 140.5 hours since the last inspection and was installed on the MA on 29 March 2012. All engine work packages were reviewed for accuracy to include information from IMDS, Joint Oil Analysis Program (JOAP), and Comprehensive Engine Management System to determine serviceability of the ME (Tabs D-29 and D-40). A review of the documents shows that no discrepancies were noted.

c. Maintenance Procedures

All aircraft forms and maintenance records show that maintenance was conducted IAW applicable Technical Orders (TOs). There are no major discrepancies in the maintenance records. None of the minor discrepancies noted had any bearing on the mishap (Tab DD-63).

There was no evidence to suggest that any maintenance procedure, practice, or performance were a factor in the mishap. There is no evidence to suggest that any maintenance actions listed in IMDS or the MA forms documentation had any bearing on the mishap (Tab DD-63).

d. Maintenance Personnel and Supervision

Interviews conducted with maintenance personnel indicated all preflight activities were normal and all personnel involved in the preflight and launch of the MA were qualified (Tabs U-112 to U-114 and Tab V-8.5). Training records of all maintenance personnel who serviced and maintained the MA revealed no evidence of training deficiencies that contributed to the mishap (Tab DD-63).

e. Fuel, Hydraulic and Oil Inspection Analyses

Fuel samples were taken and tested post-mishap from all equipment used to refuel the MA including the R11 Fuel Truck 08L549, Fuel Storage/Issue Tank #40, and Fillstand #9. All fuel samples tested were within limits and were free from contamination (Tabs D-41, D-43, D-45 to D-49, and D-51).

LOX samples were taken and tested post-mishap from all equipment used to service the MA including LOX Tank #3 and LOX Cart LC87. The samples tested were within limits and were free from any contamination (Tabs D-43 and D-50).

Because it was destroyed on impact, no fluid samples were obtained post-accident from the MA. No evidence was found that servicing equipment was a factor in the mishap (DD-63).

f. Unscheduled Maintenance

Unscheduled maintenance is any maintenance action taken that is not the result of a scheduled inspection. Unscheduled maintenance is normally the result of a pilot-reported discrepancy (PRD) during flight operations or a condition discovered by ground personnel during ground operations. There was no evidence to indicate that unscheduled maintenance was a factor in the mishap (Tab U-3 to U-99).

6. AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS.

a. Structures and Systems

At the time of the incident, all aircraft systems were operating properly (Tab J-7). The MA and its components were destroyed upon impact (Tab Q-7). Recovered wreckage was returned to AAB (Tab Q-2). The Seat Data Recorder (SDR) on the ejection seat was recovered and was sent for analysis (Tab Q-2).

b. Evaluation and Analysis

Not applicable.

7. WEATHER

a. Forecast Weather

The forecasted weather at AAB was approximately 15,000 meters visibility, rain, mist, and a broken cloud layer at 3,000 feet. There was a temporary condition between 1600L and 2000L of approximately 6,000 feet visibility, rain, mist, few clouds at 300 feet, scattered clouds at 3,000 feet, and a broken cloud layer at 5,000 feet. The forecasted weather in SARA and SPEEDY airspace between 1700L and 2000L was broken cloud layers from 1,000 to 18,000 feet and more broken cloud layers from 18,000 feet to 28,000 feet. There was forecasted light mixed icing from 3,000 feet to 15,000 feet and moderate turbulence from 18,000 to 36,000 feet. After 2000L, the weather forecast showed improvement to broken cloud layers between 3,000 and 10,000 feet and scattered clouds from 10,000 to 18,000 feet (Tabs F-2 and F-6). The forecasted sea temperature was 47 to 50 degrees Fahrenheit, with wave heights of three to six feet. Additionally, the night illumination forecast was a high illumination night, with a lunar illumination at 97% and a minimum millilux of 2.42 (Tabs F-6 and F-8).

b. Observed Weather

The observed weather at AAB was unrestricted visibility with a broken to overcast cloud layer at 12,000 feet. In the airspace, both the MF and VENOM flight observed broken to overcast cloud layer with the tops between 13,000 and 16,000 feet. SPEEDY airspace was unusable due to lack of discernible horizon. SARA airspace had a discernible horizon to the west from 180 through 360 degrees with some cultural lighting (lights from towns/villages) observed further to the west. There was no discernible horizon observed to the east (Tabs F-10, F-11, V-1.6, and V-6.4).

c. Space Environment

Not applicable.

d. Operations

The MS was conducted within the prescribed operational weather limitations (Tab DD-69).

8. CREW QUALIFICATIONS

a. Mishap Pilot (MP)

The MP was a 2003 graduate of the United States Air Force Academy (Tab G-75). At the time of the incident he was 32 years old (Tabs G-6 and CC-21). The MP completed Undergraduate Pilot Training as a member of the 80th Flying Training Wing at Sheppard AFB, Texas. He received an aeronautical rating of pilot on 8 April 2005 (Tab G-8). The MP spent the next three years as a First Assignment Instructor Pilot at Sheppard Air Force Base (AFB) as part of the 89th Flying Training Squadron (Tab G-163 to G-173). There, the MP received his initial T-37 instructor qualification on 10 June 2005 (Tab G-150). Following his initial assignment, the MP was selected for the F-16 initial qualification training at the 162nd Fighter Squadron (162 FS), Springfield-Beckley Municipal Airport, Springfield, Ohio, which he completed in December of 2009. The 162 FS Commander rated the MP as “Above Average” and awarded the MP the Red River Valley Fighter Pilot Association “River Rat” Award. The Association gives the award to the top wingman in the class and the pilot they most desired on their wing in war (Tab G-40 to G-41)).

After graduation, the MP’s next assignment was to the 555 FS, AAB. There the MP was certified as a mission capable wingman on 18 May 2010 (Tab G-159). On 16 November 2010, the MP completed his night vision goggles top off certification (Tabs G-74 and G-85). As a fully combat capable wingman, the MP took part in Operations ODYSSEY DAWN and ENDURING FREEDOM (Tab G-75). On 29 March 2012, the MP was certified as a day-only, non-Low Level or Basic Surface attack four-ship flight lead (Tab G-120). The MP’s last periodic instrument evaluation included two commendable comments: the first commended his instrument crosscheck, the second his Head-up Display (HUD)-out instrument landing system approach (Tab G-154). On 28 January 2013, the MP was flying a night 4V2 OPSAT training mission. At the time of the mishap, he had 2,341.2 total flight hours, including 149.7 NVG hours and 414.8 combat hours (Tab G-9).

The MP’s leadership and peers considered him a very good pilot and an outstanding officer. His Squadron Commander rated him in the top 10% of squadron officers and in the top 25% of squadron pilots. The commander had also selected the MP to become one of the leaders in the squadron as a Flight Commander and as the next squadron pilot to go through the Instructor Pilot Upgrade Program (Tab V-9.2 to V-9.4). At the time of the mishap, the MP had been selected for promotion to Major. He was promoted posthumously (Tab CC-21).

Recent flight time is as follows (Tab G-4):

	Hours	Sorties
Last 30 Days	8.5	7
Last 60 Days	11.2	10
Last 90 Days	20.2	16

b. Mishap Wingman (MW)

The MW was a current and qualified experienced F-16CM IP and a WIC graduate (Tab G-30). The MW was up-to-date on all his currencies required for the flight (Tab K-18). The MW's flight crew information files were signed off (Tab K-18). His records included a current critical action procedures worksheet. This is a list of emergency procedure time-sensitive actions that every pilot must know and fill out on a monthly basis (Tab G-25). At the time of the mishap, the MW had 1,448.2 total flight hours including 297.2 combat hours (Tabs G-25 and G-36).

Recent flight time is as follows (Tab G-36):

	Hours	Sorties
Last 30 Days	8.2	7
Last 60 Days	20.8	17
Last 90 Days	35.2	27

There is no evidence to suggest crew qualifications were a factor in this mishap.

9. MEDICAL

a. Qualifications

The MP was medically qualified for flying duty at the time of mishap. The MP's most recent Periodic Health Assessment was accomplished 9 January 2013. The MP's last dental exam was accomplished on 28 March 2012 with a Dental Classification of 1, and indicated no unresolved dental health problems. The MP possessed two waivers for medical conditions inconsistent with flying duty. The MP was granted an indefinite Flying Class One waiver by Air Education and Training Command (AETC) on 26 August 2002 and granted an indefinite Flying Class Two waiver by United States Air Forces in Europe (USAFE) on 31 August 2010 (Tab X-3). The MP's medical records contain a current Medical Recommendation for Flying or Special Operational Duty SF Form 1042, dated 9 January 2013. MP was required to wear vision correction devices and acknowledged use of soft contact lenses (Tabs X-3 and DD-123).

b. Health

The MP was in excellent health prior to this mishap. He exercised regularly and ate a healthy diet (Tabs X-3 to X-4 and DD-75 to 108).

c. Pathology and Toxicology

The Italian authorities conducted an autopsy on 5 February 2013 and released a preliminary statement of death. The preliminary statement of death indicated the cause of death was due to strangulation and consequent cardiac failure (Tab X-11). On 14 March 2013, after several informal attempts, the Accident Investigation Board formally requested information from the Italian authorities regarding the autopsy and the MP's cause of death. On 21 March 2013, the Italian authorities responded in writing, as at this phase in the Italian investigation the Italian coroner falls under the prosecutor's jurisdiction. This response was received by the AIB on

29 March 2013 (Tab X-11). The AIB was unable to consider the Italian coroner's final determination as to the cause of death because he had not completed his full autopsy report by the conclusion of the Accident Investigation Board (Tab X-11).

The Armed Forces Medical Examiner System (AFMES) at Dover AFB, Delaware is legally responsible for conducting autopsies on U.S. service personnel and is responsible for determining the official cause of death (See 10 U.S.C. § 1471). The AFMES Deputy Chief Medical Examiner conducted an autopsy on 9 February 2013. There were limitations on the autopsy conducted at Dover AFB as a result of the previous autopsy conducted by Italian authorities (Tabs X-7 and X-9). Regardless of these limitations, the AFMES Deputy Chief Medical Examiner determined the cause of death as multiple injuries of accidental cause occurring during the mishap sequence (Tabs X-3, X-7 and X-8).

On 29 March 2013, the Italian authorities notified the AIB that the determination of the cause of death had not been finalized. The Italian authorities explained that the MP suffered serious trauma which resulted in multiple injuries but stated that while the injuries were significant and likely caused loss of consciousness they may not have been fatal. Consequently, the Italian authorities are investigating the possibility of drowning and steering away from a diagnosis of death by strangulation and cardiac failure. The letter indicates that the Italians are awaiting the results of a strontium analysis which will further help them determine the specific cause of death (Tab X-11).

The AIB conducted an interview with the AFMES Deputy Chief Medical Examiner to allow the examiner to explain the AFMES-assigned cause of death (Tab X-7). The Deputy Chief Medical Examiner stated that although there were some technical limitations imposed by conducting a second autopsy, there was sufficient evidence to reach a firm conclusion regarding the cause of death. The Deputy Chief Medical Examiner stated that the MP suffered injuries to the head and neck, and that when taken together, would have been rapidly fatal to the MP (Tab X-7).

The AFMES Deputy Chief Medical Examiner stated the bruising on the MP's neck could have been caused by an elastic strap the MP was wearing around his neck or possibly the helmet strap. He stated the bruising is not consistent with a diagnosis of strangulation, especially in the absence of injury to deep neck muscles (Tabs X-7 and X-11).

The AFMES Deputy Chief Medical Examiner noted that the diagnosis of drowning is one of exclusion, meaning that it is considered when all other causes are ruled out (Tab X-7). The AFMES Deputy Chief Medical Examiner reviewed photos of the initial, Italian autopsy and made only one finding that could support a conclusion of drowning, that is, the possibility of hyper-inflated lungs. He also noted that there are other reasons, besides drowning, to have hyper-inflated lungs (Tab X-7). Strontium analysis of the heart is a technical study sometimes used in Europe for cases of salt water drowning. Strontium analysis is not well credited or used in the United States to rule in death by drowning (Tab X-7 to X-8). A special effort is required while extracting the blood in order to have a reliable outcome, and the USAF physician observing the Italian autopsy did not recall a special effort being taken (Tab X-9). While diagnosis of drowning cannot be definitively ruled out, it is highly unlikely due to the grievous nature of the MP's brain and neck injuries (Tab X-7). The AFMES Deputy Chief Medical Examiner found only one potential indicator of drowning, but his examination overwhelmingly pointed away from drowning as the cause of death due to the grievous nature of the MP's brain and neck injuries (Tab X-7 to X-8).

The MP suffered additional musculo-skeletal injuries to the left lower leg and right elbow (Tabs X-3 and X-7). Toxicology tests conducted by the AFMES on the MP were negative (Tab X-3 to X-4).

MF members and maintainers associated with the MA provided samples for toxicology testing. All samples were negative. There is no evidence to indicate that any legal or illegal substances were a factor in the mishap (Tab X-4).

d. Lifestyle

The MP's spouse (MPS) completed non-privileged 14-day and 72-hour histories. According to the MPS, the MP was well prepared for the MS, and there is no evidence to suggest MP's habits, behaviors, stressors, or lifestyle factors were factors in the mishap (Tab DD-75 to 108).

e. Crew Rest and Crew Duty Time

Air Force Instruction (AFI) 11-202, *General Flight Rules*, Volume 3, paragraph 9.4.5, requires pilots to have "crew rest" before participating in flying duties. According to the AFI, "[t]he crew rest period is normally a minimum 12-hour non-duty period before the flight duty period (FDP) begins. Its purpose is to ensure the aircrew member is adequately rested before performing flight or flight related duties. Crew rest is free time, and includes time for meals, transportation, and rest. Rest is defined as a condition that allows an individual the opportunity to sleep." According to the AFI, paragraph 9.8, the 12 hours prior to flight must include the opportunity for 8 hours of uninterrupted sleep (Tab BB-4 to BB-5). Additionally, the USAFE supplement to AFI 11-202, *General Flight Rules*, Volume 3, dated 19 March 2012, stipulates that the maximum flight duty period for night operations is 10 hours (Tab BB-8).

The MP's duty and sleeping patterns prior to the mishap were analyzed using the Fatigue Avoidance Scheduling Tool (FAST) developed by Dr. Steven Hursh of Science Applications International Corporation under license to the Department of Defense. The model equates fatigue with Blood Alcohol Concentration (BAC). A FAST rating of 80% is equivalent to an approximate BAC of 0.05%. The model can produce results exceeding 100% effectiveness. Analysis reveals that the MP was operating at peak cognitive effectiveness of 101% at the time of mishap (Tabs X-5 and DD-19 to DD-20).

The MP reported to work at 1130L on 28 January 2013 IAW the scheduled "report no earlier than" time (Tab K-3). At the time of the mishap, the MP was well within the 10-hour flight duty period prescribed by AFI 11-202.

There is no evidence to suggest that crew rest and duty time requirements were a factor in this mishap.

10. OPERATIONS AND SUPERVISION

a. Operations

The operations tempo for the 510 FS was normal at the time of the mishap. At the time of the mishap, the 510 FS had 31 assigned and attached pilots. Of those, 20 were experienced pilots and of those, 19 were instructor pilots (Tabs K-3, G-30, and V-9.5).

b. Supervision

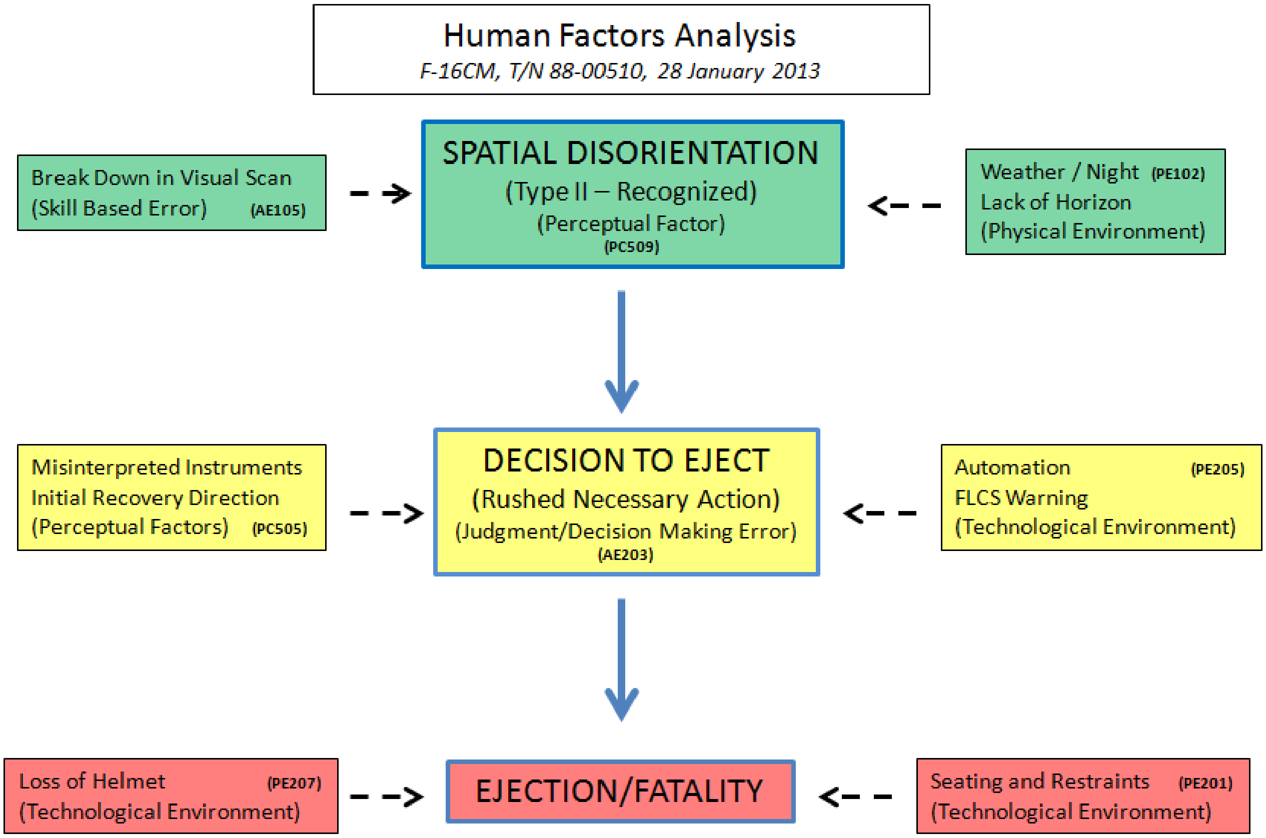
The 510 FS TOP 3 authorized this mission (Tab K-16 to K-18). On the day of the MS, the MP was trained and qualified to accomplish the assigned mission (G-3). There is no evidence to suggest that supervision was a factor in the mishap or the MP's death.

11. HUMAN FACTORS

The AIB considered all human factors as prescribed in the Department of Defense Human Factors Analysis and Classification System (DoD HFACS) as delineated in Air Force Instruction (AFI) 91-204, *Safety Investigations and Reports*, Attachment 5, 24 September 2008, to determine those human factors that directly related to the mishap (Tab BB-10 to BB-42).

Human factors analysis is speculative in nature. This mishap resulted in the death of the MP and limited direct evidence is available for the human factors analysis. Every effort has been made to gather the pertinent and available facts of the mishap and demonstrate through deductive reasoning how they impacted the mishap sequence of events.

The human factors analysis is broken down into three phases in order to assist understanding of the mishap sequence. (See Chart, below.) Phase I consists of analysis of why the MP may have become spatially disoriented. Phase II examines why the MP may have chosen to eject from the MA. Phase III examines what factors around the ejection sequence may have contributed to the MP's cause of death. In particular, Phase III examines the interaction between the MP and the safety equipment designed to prevent injury during the ejection sequence.



* Chart prepared by AIB members, derived from factors described in AFI 91-204, *Safety Investigations and Reports*.

a. Phase I: Factors Affecting Spatial Disorientation

Vision Restricted by Meteorological Conditions (PE102) is a factor when weather, haze, or darkness restrict the vision of the individual to a point where normal duties were affected (Tab BB-22).

Eyewitness reports indicate that the weather was broken with a predominant cloud layer between 15,000 and 17,000 feet sloping from east to west. SPEEDY airspace to the east of SARA was unusable due to reduced visibility and a lack of discernible horizon. SARA had a discernible horizon to the west from 180 through 360 degrees, no discernible horizon to the east and an under-cast layer above the water with some cultural lighting (towns/villages) observed further to the west (Tabs F-10, F-11, R-8, S-2, V-1.6 and V-2.3).

The weather precluded the primary planned mission, so the MP and MW coordinated two simulated bomb attacks as a backup mission (Tabs N-8, N-9, and S-2). The first attack, which did not include any simulated defensive threat reactions, was executed without incident (Tabs N-9, and S-2). During post-attack egress on the second attack, the MP initiated a series of defensive threat maneuvers (Tab DD-8, and as detailed in this AIB Report, Summary of Facts, Section 4). The MA was heading East through North East during the defensive threat reactions and towards an area of the sky that lacked a discernible horizon (See Summary of Facts, Section 4, Figures 1, and 3 through 6, and Tabs F-10, F-11, R-8. S-2, V-1.6, V-2.3, DD-8). The MA entered an extreme nose low attitude with a high rate of descent (Tab DD-8). The MA descended below 17 thousand feet during the mishap sequence which would have placed the MA inside the broken cloud layers documented in the preceding paragraph (See also, Summary of Facts, Section 4, Figures 1 and 3) .

Visual references provide the most important sensory input to the brain and its ability to maintain spatial orientation during flight. They provide information about distance, speed, depth and orientation (see, *Basic Flight* Physiology, 3rd Edition, Richard O. Reinhart, McGraw-Hill, New York, 2008, p. 127). As the MP flew on an easterly heading he may not have been able to identify the true horizon with his night vision goggles and would have had to rely on instruments and head-up display (HUD) for orientation to an artificial horizon (Tabs N-8, V-5.3, and V-10.2; see also, AFMAN 11-217, Volume 3*, Supplemental Flight Information*, 23 Feb 2009).

Vision can be divided into two types, focal and ambient vision. The distinction between focal and ambient vision is important when considering the role of vision in determining spatial orientation during flight. When there is good visibility and a clearly defined horizon, the pilot employs the peripheral ambient visual system for spatial orientation. The task requires little conscious processing (see, *Basic Flight Physiology, 3rd Edition*, Richard O. Reinhart, McGraw-Hill, New York, 2008, p. 143). When flying at night under instrument meteorological conditions (IMC) a pilot determines aircraft orientation through the use of flight instruments, which must be learned and requires the use of focal vision (see, *Ernsting's Aviation Medicine, 4th Edition*, Edited by David J. Rainford and David P. Gradwell, Oxford University Press Inc., New York, 2006, pp. 294-295).

The focal visual system used in instrument flying is not the natural orientation mechanism and requires more cognitive processing than when external visual cues are used for orientation (see, *Ernsting's Aviation Medicine, 4th Edition*, Edited by David J. Rainford and David P. Gradwell, Oxford University Press Inc., New York, 2006, pp. 295). Spatial disorientation (SD) is thus more likely to occur during flight in IMC (see, AFMAN, Volume 1, *Instrument Flight Procedures*, 22 Oct 2010, para. 2.5 and AFMAN 11-217, Volume 3, *Supplemental Flight Information*, 23 Feb 2009, para 12.14)

Breakdown in Visual Scan (AE105) is a factor when the individual fails to effectively execute learned or practiced internal or external visual scan patterns leading to an unsafe situation (Tab BB-19 to BB-20).

MP was a competent instrument pilot and had been commended on his last instrument check ride for his instrument cross check (Tab G-154). This evidence supports a finding that the MP was competent and practiced at executing cockpit visual scan patterns.

The MP's intended altitude block was 20,000 to 24,000 feet (Tab N-8). It is reasonable to assume that the MP intended to keep the MA above 20,000 feet. The MA entered an unsafe attitude after the MP executed his "last ditch" threat reaction descending below 20,000 feet in an extreme nose low altitude with a high rate of descent (Tab DD-8).

The MP was wearing NVGs while conducting a threat reaction against a simulated surface to air missile (Tabs V-1.3 and DD-8). The MP initiated a “last ditch” maneuver at 19:49:03L and 10 seconds later at 19:49:13L made a radio call that he was suffering from spatial disorientation (Tabs DD-8 and N-17). In a “last ditch” maneuver the pilot attempts to defeat the threat by visually acquiring the incoming SAM while aggressively maneuvering the aircraft (Tab DD-69). Consequently, it is reasonable to conclude that the MP looked outside of the MA and towards the perceived location of the simulated missile in order to correctly practice the threat reaction.

At 19:49:16L, the MW instructed the MP to look at the round dials and the MP immediately oriented the MA to the horizon (Tab N-17). The MP initially oriented the MA to the inverted horizon but by 19:49:18L had reoriented the MA to the correct horizon and started to recover the MA from its unusual attitude (Tab DD-9). The MP recovered the MA efficiently and quickly upon being prompted to return his visual scan to the cockpit instruments.

A proper visual scan includes a cross-check of the environment outside the aircraft, along with aircraft flight instruments. Together these provide the pilot situational awareness with respect to an accurate estimation of the aircraft’s attitude and orientation (see, *Spatial Disorientation in Aviation*, Edited by Fred H. Previc and William R. Ercoline Published by the American Institute of Aeronautics and Astronautics, Inc., Reston, Virginia, 2004, p. 394).

ANVIS-4949 NVGs used in the mishap sortie (MS) have a 40-degree field of view (see, *Ernsting's Aviation Medicine, 4th Edition*, Edited by David J. Rainford and David P. Gradwell, Oxford University Press Inc., New York, 2006, pp. 291). The human eye has an almost 180-degree field of view (Tab DD-145). The NVG field is more limited than the eyes and causes a loss of peripheral vision, which can be a factor in spatial disorientation (see, AFMAN 11-217, Volume 3, *Supplemental Flight Information*, 23 Feb 2009, para. 12.8). Viewing the horizon through the NVGs when 30 degrees from the horizon requires increased movement of the head and neck (Tab DD-145 to DD-146 and see, *Spatial Disorientation in Aviation*, Edited by Fred H. Previc and William R. Ercoline Published by the American Institute of Aeronautics and Astronautics, Inc., Reston, Virginia, 2004, p. 19). The environment outside the cockpit may have been degraded as discussed above (section on “Vision Restricted by Meteorological Conditions”), meaning that cockpit instruments may have been the sole indicator of the MA’s orientation.

Visual cross-referencing of flight instruments provides additional data about aircraft orientation, which may offset any diminished visual ambient cues (see, *Ernsting's Aviation Medicine, 4th Edition*, Edited by David J. Rainford and David P. Gradwell, Oxford University Press Inc., New York, 2006, pp. 294-295). A good instrument cross check and control of the aircraft by reference to the primary flight instruments is integral to United States Air Force (USAF) pilot training and techniques. This training aims at preventing the pilot from succumbing to the effects of spatial disorientation (Tab DD-145 and see, AFMAN, Volume 1, *Instrument Flight Procedures*, 22 Oct 2010).

Spatial Disorientation (SD) (Type 2) Recognized (PC509) is a failure to correctly sense a position, motion, or attitude of the aircraft or of oneself within the fixed coordinate system provided by the surface of the earth and the gravitational vertical. SD (Type 2) is a factor when recognized perceptual confusion is induced through one or more of the following senses: visual, vestibular, auditory, tactile, proprioception or kinesthetic. During SD (Type 2), proper control inputs are still possible (Tab BB-32).

The MP recognized that he was spatially disoriented at 19:49:13L approximately 12 seconds after initiating the last ditch maneuver and 12 seconds prior to ejecting (Tab DD-8). Data from the MA reflect a lack of control input for the 8 seconds preceding the MP's announcement that he was spatially disoriented (Tab DD-8). MA data reflect that the MP attempted a recovery maneuver once instructed by the MW to "look at the round dials" (Tab N-17).

A pilot can become disoriented in several ways. The brain processes several sources of sensory inputs for orientation. These sources of input are vision, vestibular, proprioceptor, and, to a lesser extent, auditory cues. Vision provides the strongest cues and is usually the most accurate of the senses (see, *Basic Flight Physiology*, 3rd Edition, Richard O. Reinhart, McGraw-Hill, New York, 2008, p. 127).

Maintaining spatial orientation at night requires a conscious processing of data from various instruments, displays and references. The task of maintaining spatial orientation competes with other flight tasks. To help prevent SD, the pilot must maintain constant vigilance and a good scan, both inside and outside the cockpit. NVGs can assist with avoiding SD when good external cues are available (see, AFMAN 11-217, Volume 3, *Supplemental Flight Information*, 23 Feb 2009, para. 12.14). This mishap is notable for a lack of external visual cues through approximately 180 degrees of the horizon and complicated by a sloping cloud deck in other parts of the horizon (Tab R-8). The evidence shows that the MP made no control inputs for the 8 seconds preceding his admission of SD while the MA lost about 5,000 feet of altitude (Tab DD-8 and DD-9). The MP's delay in recognizing and attempting to recover from SD cost valuable time and altitude compressing the time available for the MP's follow on decision-making.

b. Phase II: Factors Affecting Ejection Decision

Automation (PE205) is a factor when the design, function, reliability, use guidance, symbology, logic or other aspect of automated systems creates an unsafe situation.

Flight Control System (FLCS) fail and master caution lights illuminated shortly after the MP initiated his threat reaction. This was due to the MA exceeding angle of attack limits while the autopilot was engaged (Tab J-5). An aural warning message would have followed seven seconds after illumination of the master caution light (Tab J-5). The warning lights and aural warning would have increased the MP's cognitive tasking during the threat reaction, causing distraction (see, *Spatial Disorientation in Aviation*, Edited by Fred H. Previc and William R. Ercoline Published by the American Institute of Aeronautics and Astronautics, Inc., Reston, Virginia, 2004, p. 175).

The MP's personal notebook reveals notes he used to prepare a briefing on the predictive ground collision avoidance system (PGCAS) available in the F-16CM. His briefing notes indicate the plan to set the PGCAS value to 125 feet and to initiate a 5-6 G pull up if the avionics system advised initiation of a pull up (Tab DD-119). There is no direct evidence on this point, these briefing notes are circumstantial evidence regarding the actual value the MP used in the PGCAS the night of the mishap. If the MP set the PGCAS to 125 feet and the PGCAS system was functioning normally, it is highly likely the MP would have received a pull up warning sometime after he initiated his last ditch maneuver (Tab DD-11 and DD-12).

Misinterpreted/Misread Instrument (PC505) is a factor when the individual is presented with a correct instrument reading but its significance is not recognized, it is misread or is misinterpreted (Tab BB-32).

The MP was well trained in the use of instruments and had demonstrated above average use of cockpit instruments on his last instrument check ride (Tab G-154). The MP initiated a recovery maneuver to the furthest away horizon when prompted to recover by the MW. This means that instead of turning the MA up to face the near horizon the MP turned the MA onto its back (inverted) and would have had to point the nose at the ground before pulling up to the horizon (Tab DD-8 to DD-9).

The F-16 Attitude Direction Indicator (ADI) is the primary flight instrument giving the pilot an artificial awareness of the horizon and was the primary instrument to which the MW was referring when he instructed the MP “to get on the round dials” (Tab N-17). Note that in the aircraft, the ground is indicated by the color brown and the sky is indicated by the color blue. The horizon line between the brown and blue fields is a strong cue to the horizon and gives an excellent indication of how far the horizon is from the nose of the aircraft (indicated by the dot in the middle of the yellow W symbol) (Tab DD-146). The ADI is depicted below for level flight (Figure 11).

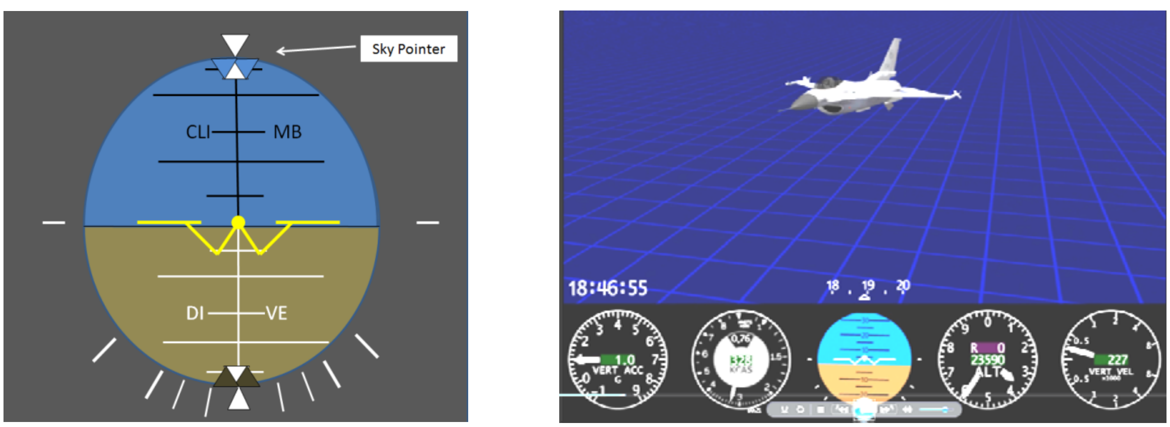


Figure 11. Straight and level flight. Tab Z-8

If the aircraft is more than 25 degrees nose low, there is no evidence of blue and the primary horizon line is not viewable in the ADI (see figures 12 and 14). This situation leaves the sky pointer as the primary cue to the nearest horizon. The sky pointer is always visible and is indicated by the white triangle pointing at the blue field behind it (see, AFMAN 11-217, Volume 1, *Instrument Flight Procedures*, 22 Oct 2010, para. 2.5.3.3).

Visibility of the ADI can be difficult at night when using NVGs. Cockpit lighting is normally turned down as low as possible while still allowing for clear viewing of instruments. The viewing of instruments is affected by dark adaptation. Dark adaptation is a process during which the eye becomes more sensitive to vision in dark environments. Dark adaptation of central vision usually takes about 6 to 8 minutes (see, *Fundamentals of Aerospace Medicine, 4th Edition*, Jeffrey R. Davis, Robert Johnson, Jan Stepanek, Jennifer A. Fogarty Lippincottt, Williams & Wilkins, Philadelphia, 2008, p. 357). NVGs are normally put in place sometime after takeoff while the pilot flies on instruments up to the point that NVGs are put in place. Once NVGs are in place, they diminish the eye's dark adaptation since the NVG display consists of bright light. It is often necessary to turn up portions of the cockpit lighting once NVGs are in place (Tab DD-146). The status of the MP's cockpit is not known but it is feasible and possible that the main ADI could have been sub optimally illuminated if the MP had adjusted the cockpit lights for best visual acuity on takeoff and forgot to re-adjust the cockpit lighting once he had donned NVGs (Tab DD-146).

Figure 12 depicts the appearance of the main ADI seven seconds prior to the MP declaring that he was spatially disoriented (Tab DD-8 and N-17). The MP would have seen a brown field with no blue horizon when prompted by the MW to refer to the round dials (Tab N-17). Evidence shows that the MP aligned the aircraft with the horizon bar but incorrectly interpreted which way was up (Tab DD-9). Transition from NVGs to the round dials once the MA attitude was greater than 25 degrees below the horizon left the MP with fewer cues as to which direction to turn for the most efficient recovery and may explain why the MP initially turned in the wrong direction.

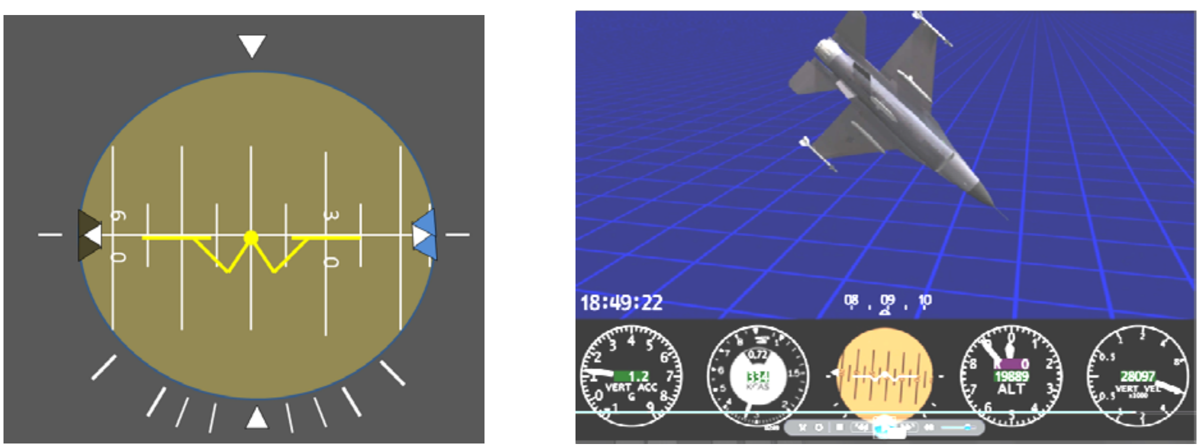


Figure 12. MA at 19:49:06L – 40 degrees nose low and 90 degrees left bank.
(The depictions on the right list times that are 59 minutes and 44 seconds in error from the actual mishap time sequence (Tab DD-5).)

Once the MP reached 70 degrees nose low, a round ball appeared in the ADI indicating a straight down pointing at the earth direction referred to in Figure 13. The MP reoriented the MA to the correct horizon within one second of the time that the "earth" ball would have come into view in the ADI (Tab DD-9).

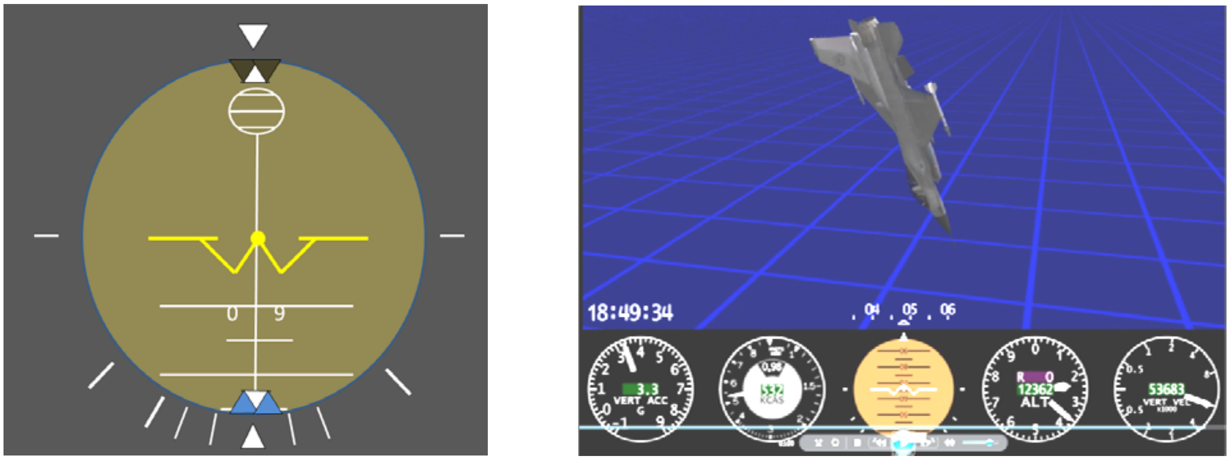


Figure 13. MA at 19:49:18L – 70 degrees nose low and 180 degrees bank. (The depictions on the right list times that are 59 minutes and 44 seconds in error from the actual mishap time sequence (Tab DD-5).)

The MW advised the MP to "look at the round dials, disregard the HUD" three seconds after the MP declared "knock it off, I'm spatial D" (Tab N-17). Early HUDs had simple symbology and were often implicated in exacerbating spatial disorientation. Modern HUDs have a wealth of information designed to orient the pilot to the horizon and have proven reliable (see, *Spatial Disorientation in Aviation*, Edited by Fred H. Previc and William R. Ercoline Published by the American Institute of Aeronautics and Astronautics, Inc., Reston, Virginia, 2004). AFMAN 11-217, Volume 1, *Instrument Flight Procedures*, 22 Oct 2010, paragraph 2.5.1, contains a warning to transition to instruments any time spatial disorientation is encountered. A second warning cautions pilots to disregard visual information from night vision goggles until orientation is re-established. Pilots are instructed to recognize unusual attitudes by primarily referencing the ADI (see, AFMAN, Volume 1, *Instrument Flight Procedures*, 22 Oct 2010). There are no prohibitions on use of the HUD as an adjunct to aid in spatial orientation and in fact they may prove helpful (Tab DD-146 and see, *Spatial Disorientation in Aviation*, Edited by Fred H. Previc and William R. Ercoline Published by the American Institute of Aeronautics and Astronautics, Inc., Reston, Virginia, 2004).

Necessary Action – Rushed (AE203) is a factor when the individual takes the necessary action as dictated by the situation but performs these actions too quickly and the rush in taking action leads to an unsafe situation (Tab BB-20).

The ejection seat left the MA at 19:49:25L as the MA approached 16 degrees nose low at just over 7,000 feet and 569 knots (Tab DD-9). At the time of ejection, the MA was essentially recovered from its unusual attitude and the MA flew for an additional four miles before impacting the water (Tabs DD-9 and S-3). Human response time-lag reasonably approaches one second or longer. Response lag is the delay between perceiving the need for an action and being able to execute the action. (see, *Fundamentals of Aerospace Medicine, 4th Edition,* Jeffrey R. Davis, Robert Johnson, Jan Stepanek, Jennifer A. Fogarty Lippincottt, Williams & Wilkins, Philadelphia, 2008, p. 364). Flight data also shows a decrease in demanded G forces one second prior to ejection indicating the MP had likely let go of the controls. Therefore it is likely that the MP initiated ejection at 19:49:23L at which time the MA was 25 degrees nose low, 7,900 feet and 568 knots (Tab DD-9). This attitude is depicted in Figure 14 below. Note the lack of blue horizon.

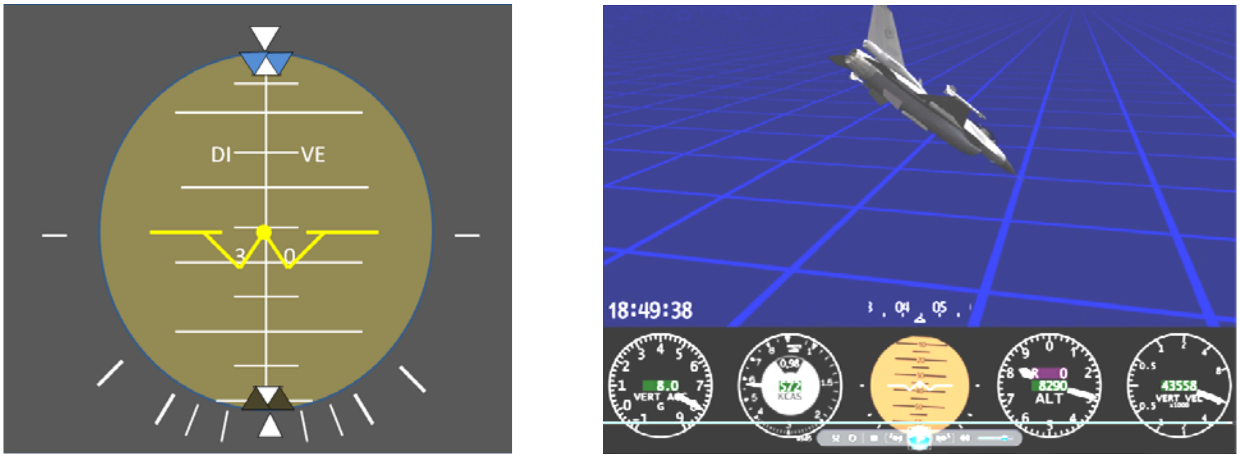


Figure 14. MA at 19:49:22L – 25 degrees nose low and wings level (3 seconds prior to ejection). (The depictions on the right list times that are 59 minutes and 44 seconds in error from the actual mishap time sequence (Tab DD-5).)

The MP participated in an Instrument Refresher Course (IRC) on 1 November 2012 (Tab G-23). The IRC covered many topics to include SD (Tab DD-125 to DD-127). The MP delivered a Wing safety brief, as Chief, Flight Safety, in March 2012. During this brief he covered spatial disorientation and emphasized the need to eject if SD and unable to recover (Tab DD-109 to DD-111). Ejection is the correct course of action if a pilot perceives that he cannot recover from SD (Tab BB-55). Six thousand feet is a generally accepted minimum altitude to eject when aircraft control is lost due to mechanical or physiologic reasons (Tab DD-146). The MP stated he was SD and ejected while still above 6,000 feet and with the aircraft in no danger from imminent ground contact. The MA had not passed through 6,000 feet when ejection was commanded. Figure 14 shows the MA descent rate was approximately 45,000 feet per minute which translates to about 750 feet per second. Hence, the MP had two to three additional seconds to analyze and decide upon a course of action before the MA passed through 6,000 feet. If the MP had delayed the decision by three seconds to time 19:49:26L (one second after ejection was commanded) the MA's primary attitude indicator would have shown a prominent brown-blue horizon line indicating that the MA was recovering and in control (Tab DD-9).

c. Phase III: Factors Affecting Ejection / Contributing to Fatal Injuries

Seating and Restraints (PE201) is a factor when the design of the seat or restraint system, the ejection system, seat comfort or poor impact-protection qualities of the seat create an unsafe situation (Tab BB-23).

Section 4, Sequence of Events, sub-paragraph (f), discusses the technical aspects of the AFE. The following section discusses the interaction between the AFE and MP leading to an unsafe situation.

Post ejection analysis of the ejection seat reveals that the right shoulder harness retracted 1.5 inches less than the left shoulder harness when the shoulder harness retraction reel was initiated after ejection (Tab DD-161). The AIB was unable to determine the cause for the disparity between the left and right shoulder harnesses. Condition and tightness of the MP's lap belt is unknown. High-speed ejection subjects the seat occupant to very high dynamic forces from wind blast. Any slack in the seat restraint system can subject the seat occupant to forces pushing their upper torso, head and neck outside the confines of the seat head box, increasing exposure to injury (Tabs DD-69 and DD-147).

Personal Equipment Interference (PE207) is a factor when the individual's personal equipment interferes with normal duties or safety.

Post-mishap analysis of the aircrew flight equipment indicates the MP's helmet separated from his head shortly after ejection was initiated (Tab DD-163). The MP's unprotected head was then subject to lethal lateral and rotational forces (Tab X-3). The MP was wearing the HGU-55/P helmet also known as the 55P Helmet-Mounted Cueing System (HMCS) helmet (Tabs DD-133 and DD-138 and Tab DD-157). Review of technical order guidance, multiple high-speed rocket sled ejection test results and a broad cross section of literature reveals that the HMCS helmet is unlikely to stay in place at high speeds (Tab DD-69). Loss of the helmet through windblast forces can cause severe injury to the pilot (Tab DD-147).

Life sciences analysis concludes the helmet was lost upon exposure to the initial windblast (Tab DD-163). The helmet was missing any witness marks from contact with the seat, suggesting it was no longer on the MP's head during the "head slamback," which occurs microseconds after ejection is initiated (Tab DD-161). The MP's injury pattern of abrasions and lacerations to the face and head suggests that the MP's helmet was lost to windblast early in the ejection sequence (Tab X-3). The cord for the MP's in ear communication devices was found wrapped around the left pitot tube of the ejection seat (Tab DD-161). The in ear communication devices are custom molded ear plugs with an embedded speaker and cannot be removed from the ears without removing the helmet. The pitot tubes are part of the parachute container that departs the seat approximately 1.17 seconds after ejection (Tabs DD-161 and H-3). The bulk of evidence indicates that the MP lost his helmet immediately upon ejection. The MP's unprotected head and neck were injured in the windblast and were likely further injured upon the 40+ G correction to seat yaw, which occurred approximately 0.3 seconds post ejection (Tab DD-52). The effect of this likely caused the MP's fatal injuries (Tabs DD-52, DD-55, X-3 and see, *Injury Criteria and Human Tolerance for the Neck*, Channing L. Ewing, Aircraft Crashworthiness, University Press of Virginia, Charlottesville, 1975).

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Publicly Available Directives and Publications Relevant to the Mishap

(1) Air Force Instruction (AFI) 11-2F-16, Volume 1, *F-16--Pilot Training*, 11 August 2011

(2) AFI 11-2F-16, Volume 3, *F-16--Operations Procedures*, 25 April 2012

(3) AFI 11-202, Volume 2, *Aircrew Standardization/Evaluation Program*, 13 September 2010, Incorporating Change 1, dated 18 October 2012
(4) AFI 11-202, Volume 3, *General Flight Rules*, 22 October 2010
(5) AFI 11-202, Volume 3, *General Flight Rules*, 22 October 2010, United States Air Forces in Europe Supplement, 19 March 2012
(6) AFI 11-202, Volume 3, *General Flight Rules*, Aviano Air Base Supplement, 19 March 2012
(7) AFI 11-214, *Air Operations Rules and Procedures*, 14 August 2012
(8) AFI 11-301, Volume 1, *Aircrew Flight Equipment Program*, 25 February 2009, Certified Current 8 March 2011
(9) AFI 11-301, Volume 1, *Aircrew Flight Equipment Program*, United States Air Forces in Europe Supplement, 22 September 2009
(10) AFI 48-123, *Medical Examinations and Standards*, 24 September 2009
(11) AFI 91-204, *Safety Investigations and Reports*, 24 September 2008, with Air Force Guidance Memorandum, 9 August 2012
(12) AFMAN 11-217, Volume 1, *Instrument Flight Procedures*, 22 October 2010
(13) AFMAN 11-217, Volume 3, *Flying Operations, Supplemental Flight Information*, 23 February 2009, Certified Current, 9 April 2012

NOTICE: All directives and publications listed above are available digitally on the AF Departmental Publishing Office internet site at: http://www.e-publishing.af.mil.

b. Other Directives and Publications Relevant to the Mishap

(1) AFTTP 3-3., *F-16 Combat Aircraft Fundamentals F-16*, 29 June 2012
(2) TO 00-20-1, *Aerospace Equipment, Maintenance Inspection, Documentation, Policies, and Procedures*, 1 September 2010
(3) TO 12S10-2AVS-2, *Image Intensifier Set, Night Vision, Type An/Avs-9*, Change 4, 23 July 12
(4) TO 13A5-56-11, *Escape System Assemblies*, Change 21, 20 October 10
(5) TO 31r4-2urt44-11, *Identifying Technical Publication Sheet An/Urt-44 Personnel Locator Beacon*, 10 November 2011
(6) TO 14D1-3-316, *Drogue Parachute Assembly*, 12 January 12
(7) TO 14D3-10-1, *Ejection Seat Aircrew Recovery Parachute*, Change 43, dated 18 September 2012
(8) TO 14D3-11-1, *Operation, Inspection, Maintenance, And Packing Instructions For Emergency Personnel Recovery Parachute (Chest, Back, Seat Style, And Torso Harness) With Illustrated Parts Breakdown*, Change 49, 25 September 12
(9) TO 1F-16CM-1, *Flight Manual, USAF Series F-16C and F-16D, CCIP, Aircraft Blocks 40, 42, 50, and 52*, 1 August 2012
(10) TO 1F-16CM-1-1, *Supplemental Flight Manual, USAF Series F-16C and F-16D, CCIP, Aircraft Blocks 40, 42, 50, and 52*, 1 June 2012
(11) TO 1F-16CM-1-2, *Supplemental Flight Manual, USAF Series F-16C and F-16D, CCIP, Aircraft Blocks 40, 42, 50, and 52*, 1 June 2012
(12) TO 1F-16CM-1CL-1, *Flight Crew Checklist*, Change 7, 1 August 2012

(13) TO 1F-16CM-34-1-1, *Avionics and Nonnuclear Weapons Delivery Flight Manual, USAF, CCIP, Aircraft F-16C/D, Blocks 40, 42, 50, and 52*, 1 May 2012
(14) TO 14P3-1-161, *Combined Advanced Technology Enhanced Design "G" Ensemble (Combat Edge Equipment)*, Change 37, 23 June 11
(15) TO 14P3-4-151, *Operation And Maintenance Instructions With Illustrated Parts Breakdown Hgu-55/P Flyer's Helmet*, Change 11, 06 February 12
(16) TO 14P3-6-121, *Anti-G Cutaway Garment Type Csu-13b/P*, Change 25, 24 September 12
(17) TO 14S-1-102-31, USAF Flotation Equipment Low Profile Flotation Collar Lpu-38/P, Change 12, dated 22 August 12
(18) 31 FW PILOT AID (01-DEC-12)
(19) 31 OG SYLLABUS (01-DEC-10)
(20) Commercial Off-the-Shelf (COTS) Manual, Maintenance Manual, 600-series, Immersion Dry Coverall, Table 2 Survival Matrix (A/W POC for info release), Issue 13 – August 2012, published by Multifabs, Aberdeen, United Kingdom

c. Known or Suspected Deviations from Directives or Publications Not applicable.

13. ADDITIONAL AREAS OF CONCERN

Not applicable.

// SIGNED //

27 Aug 13

DEREK P. RYDHOLM
Brigadier General, USAFR
President, Accident Investigation Board

STATEMENT OF OPINION

F-16C, T/N 88-0510
NEAR CERVIA, ITALY
28 JANUARY 2013

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

1. OPINION SUMMARY

I find, by clear and convincing evidence, that the cause of the mishap was the mishap pilot's (MP) failure to effectively recover from spatial disorientation (SD), due to a combination of weather conditions, the MP's use of NVGs, the MA's attitude and high rate of speed, and the MP's breakdown in visual scan. This led the MP to misjudge the imminent need to eject. I also find, by clear and convincing evidence, that an immediate loss of the MP's helmet upon the high-speed ejection, slack in the ejection seat harness, and a left yaw to the ejection seat as it left the mishap aircraft (MA), along with the 40 gravitational force (G) snapback that followed the ejection seat's drogue chute deployment, caused the MP's injuries, which quickly resulted in his death.

On 28 January 2013, at approximately 1903 hours local time (L), an F-16CM, tail number 88-0510, assigned to the 510th Fighter Squadron (510 FS), 31st Fighter Wing (31 FW), Aviano Air Base (AAB), Italy, departed AAB as part of a formation of three F-16CM and one F-16DM aircraft engaged in a night 4V2 (Four Friendly Against Two Enemy Aircraft) opposed surface attack tactics training mission using night vision goggles. The MF mission was to act as four friendly aircraft attacking enemy ground targets. Two enemy aircraft, simulated by VENOM flight, were to protect those targets. At 1949L, approximately 46 minutes after takeoff, the MP executed a "last ditch" defensive maneuver to avoid a simulated surface-to-air missile (SAM) threat, as part of the training mission. This ultimately resulted in the MP initiating ejection from the MA. Injuries sustained in the ejection were fatal. The MA flew approximately four miles from the ejection site and was then destroyed upon impact with the Adriatic Sea. The loss of the MA and its associated property is valued at $28,396,157.42. There was no other damage to government or private property.

At the time of the mishap, the MP was assigned to the 31 FW Safety Office and was attached to fly with the 555 Fighter Squadron (FS). On the night of the Mishap Sortie (MS), the MP was completing his final night flight lead upgrade (FLUG) ride. Since the 555 FS was off station, the MP was flying in the 510 FS during the MS. The MP was the flight lead. After departure and upon entering the primary airspace, the MP encountered limited visibility conditions along with a lack of discernible horizon, caused by layered clouds and haze. The MP attempted to find airspace clear of clouds to execute the primary mission. Unable to do so, the MP appropriately simplified the mission. In order to utilize the workable portion of the airspace, the MP split the formation into two separate, two-aircraft flights. The MP directed measures to allow the two flight leads to brief and execute their backup missions in the limited available airspace. The MW, who was also the instructor pilot (IP) of record evaluating the MP on his FLUG sortie, agreed with the MP that level bombs on coordinates (BOC) attacks would provide the best possible training. The first attack was executed successfully and did not include any threat reactions. During the egress portion of the second attack, the MP called out a simulated SAM being fired at the MW, resulting in the MW executing a successful threat reaction. Approximately 20 seconds later, the MW called out a simulated SAM being fired at the MP. The MP then initiated a threat reaction. At 19:48:57L the MW radioed “missiles your right 3 o’clock, 6 miles.” This meant that the simulated SAM was tracking the MA, off of the MP’s right wing for six miles. The MP then initiated a “last ditch” defensive maneuver, which resulted in the MA entering a 45 degree nose low, 90 degree left wing down, attitude. At 19:49:13L the MP called “knock it off, I’m spatial D.” “Knock it off” procedures are used to direct aircraft or aircrew to stop engagements, scenarios and tactical maneuvering. “I’m spatial D” meant that the MP recognized that he was spatially disoriented. The MW immediately directed the MP to recover from SD by focusing on the primary aircraft attitude instrument. The MP never recovered from SD and ejected at 19:49:25L.

I developed my opinion by analyzing factual data from historical records, Air Force directives and guidance, engineering analysis, witness testimony, flight data, flight simulations, animated simulations, and information provided by technical experts. The failure to retrieve the Crash Survivable Flight Data Recorder complicated the re-creation of the mishap, and impacted my ability to determine facts in this investigation.

2. CAUSE

a. Loss of Aircraft.

As part of his training mission, the MP executed a “last ditch" defensive maneuver to avoid a simulated SAM threat. While defending against the threat, the MP, who was wearing NVGs, fixated his visual scan outside the aircraft, while at the same time looking towards an indiscernible horizon. The MP had a breakdown in visual scan, which should have included a proper cross-check of his instruments. By not cross-checking the aircraft flight instruments, the MP had entered the MA into a 45 degree nose low, 90 degree left wing down, attitude, at a high rate of descent, which was beyond what was required to defeat the simulated threat. Traveling through clouds at this time also deprived the MP of external visual cues. As a result, within a few seconds, the MP experienced spatial disorientation. It is clear that the MP experienced and recognized his SD, based on the fact he called “CLAW knock it off, I’m spatial D” over the radio. The MP’s SD resulted from several factors, including the weather conditions and the lack of a discernible horizon, the MP’s use of NVGs, the MA’s attitude and high rate of speed, and a breakdown in the MP’s visual scan.

The MP would have needed a vigorous visual scan during the mishap sequence due to the lack of external visual cues, use of NVGs, and probable focus outside the aircraft during the practice threat reaction. The MA encountered an unusual and most likely unintended attitude during the “last ditch” portion of the threat reaction. Deductive reasoning suggests the MA would not have ended up in an unusual and unexpected attitude if a consistent visual scan had been present. The MP efficiently recovered the MA when prompted to re-engage his visual scan on the cockpit instruments, giving further evidence to the lack of an effective visual scan in the moments prior to the MW telling the MP to get on the round dials. It is likely that the MP's visual scan broke down at some point during the threat reaction.

This mishap occurred at night, in poor weather, while the MP was using NVGs . The MP started a series of defensive reactions while facing a section of the sky without a discernible horizon. The MA entered an extreme nose low attitude with a high rate of descent during the defensive threat reaction while entering into cloud layers, which further deprived the MP of external visual cues. The loss of ambient visual cues increased the MP's reliance on his focal vision and cognitive processing in order to remain oriented and likely increased the MP's susceptibility to spatial disorientation.

After the MP announced he was SD, the MW directed the MP to transition to primary recovery instruments by communicating "Look at the round dials, disregard the HUD." The round dials are the primary attitude, altitude, and airspeed indicators used in unusual attitude recovery, and the HUD is the head-up display. Upon the MW's prompt to "look at the round dials," the MP initially turned away from the nearest horizon, which was the incorrect direction, due to a misinterpretation of his Attitude Director Indicator (ADI). At this point, the MA was in a 45 degree nose low dive. It is important to note that the ground in the ADI is indicated by the color brown while the sky is blue. In level flight, the line between the brown and blue fields is a strong cue to the horizon. Because of the 45 degree now low dive, this would have meant that the MP saw no evidence of blue and that the primary horizon line was not viewable in the ADI. The MP aligned the MA with the horizon bars represented on the brown portion of the ADI when prompted to recover by the MW but turned towards the farthest horizon and least efficient direction of recovery. It is possible that cockpit lighting conditions and the lack of cues available on the ADI to the direction of the closest horizon affected the MP's ability to determine the best direction to turn the aircraft for recovery. The MP quickly corrected his orientation to the closest horizon at the same time that the "earth ball" would have come into view in the main ADI. The turn in the incorrect direction resulted in the MA becoming fully inverted in a 70 degree nose low dive losing significant altitude and gaining significant airspeed.

The MP's misinterpretation of the ADI is evidence of the MP's continued SD, which consumed valuable seconds of time and persisted at least until the MP turned in the appropriate direction on the ADI and started to recover the MA. It is highly likely that at this point the MP received a pull up aural warning and accompanying symbology in the MP's multi-function displays and HUD. I reached this conclusion based on briefing notes from the MP indicating his plan to set the Precision Ground Collision Avoidance System (PGCAS) value to 125 feet. In replicating the "last ditch" maneuver in the aircraft simulator, the Board members consistently received these warnings. The warning and accompanying symbology in the MP's multi-function displays and HUD may have been unexpected to the spatially disoriented MP. The unexpected warning lights and aural warnings may have caused confusion and cognitive overload and further affected the MP's perceptions about the time available to recover the MA versus the need to eject.

During the initial stages of the attempted recovery, the MA achieved supersonic airspeeds while descending at almost 1,000 feet per second and transiting broken cloud layers. Simultaneously, the MP demanded extremely high Gs in an attempt to level off as the MA descended through

10,000 feet. It is highly likely that the combined effect of all of these factors left the MP feeling rushed, resulting in him taking actions too quickly which led to an unsafe situation, the high-speed ejection. A generally accepted minimum altitude to eject when aircraft control is lost due to mechanical or physiological reasons is 6,000 feet. The MP ejected at 7,066 feet. The MP would have had additional cues that the MA was in the process of recovering to a normal flight attitude at a safe altitude if the ejection decision had been delayed until passing through 6,000 feet. As the Chief of Flight Safety for the 31FW, the MP had previously given a safety brief which covered SD and emphasized the need to eject if spatially disoriented and unable to recover. This also likely influenced the MP's belief that he needed to eject.

The combination of all of these factors likely added to delays in the MP's ability to regain sufficient spatial orientation. These include numerous human factors, illuminating cockpit caution lights, and aural cockpit messages. Additionally, the MA's last observed altitude and the known cloud layers lead me to conclude that the MP was in the weather as he ejected, which likely would have further affected his judgment. The MP's breakdown in visual scan, combined with weather conditions and a lack of discernible horizon, caused the MP's spatial disorientation, which led to additional errors of perception, all of which led the MP to misjudge the imminent need to eject.

b. Cause of Death.

The MP ejected at 7,066 feet above the water and 569 knots (.96 Mach). This high speed ejection was within the performance envelope, that is, the acceptable range of speed, attitude, and altitude, of the Advanced Concept Ejection Seat II ejection system. The evidence shows that the ejection sequence, which includes the parachute deployment and seat separation, functioned as designed.

At ejection, the aircraft was 16 degrees nose low in an 18 degree left bank under 3.6 Gs. The canopy separated immediately after the MP initiated the ejection sequence. As the ejection seat rocket motors fired, the MP experienced an approximately 15 G downward force to the head and neck as the seat moved up the guide rails. The MP's helmet came off due to windblast in the initial stages of the ejection sequence. The force of the windblast as the seat came out of the MA then caused the MP's head and neck to flex back, likely striking some part of the ejection seat without the protection of the helmet. Additionally, the ejection seat departed the MA with a left yaw and a left lateral force rising to 10 Gs. The ejection seat continued to yaw further to the left during the remainder of the ejection sequence.

The high-speed ejection subjected the MP to very high dynamic forces from wind blast. Analysis of the MA ejection seat shows that the seat's right shoulder harness retracted 1.5 inches less than the left shoulder harness when the shoulder harness retraction reel was initiated after ejection, leaving slack in the seat restraint system. This difference in the shoulder harness's retraction lengths indicates that the MP's position in the seat was off center and to the left. This slack in the harness, combined with the ejection seat yaw, exposed the MP to the effects of the windblast while he was unprotected by the seat head box, increasing the MP's exposure to injury and causing significant head and neck trauma. At the deployment of the drogue chute, designed to stabilize the seat for ejections above 250 knots, the MP experienced at least a 40 G lateral snapback to the right. This entire sequence most probably occurred within 0.30 seconds after the

MP initiated ejection, as supported by life science and ejection seat expert analysis. A combination of an immediate loss of the MP's helmet upon the high-speed ejection, slack in the ejection seat harness, and a left yaw to the ejection seat as it left the MA, along with the 40 G snapback, caused the MP's injuries, which were rapidly fatal.

3. Conclusion

I find, by clear and convincing evidence, that the cause of the mishap was the MP's failure to effectively recover from spatial disorientation, due to a combination of weather conditions, the MP's use of NVGs, the MA's attitude and high rate of speed, and the MP's breakdown in visual scan. This led the MP to misjudge the imminent need to eject. I also find by clear and convincing evidence, that an immediate loss of the MP's helmet upon the high-speed ejection, slack in the ejection seat harness, and a left yaw to the ejection seat as it left the MA, along with the 40 G snapback that followed the ejection seat's drogue chute deployment, caused the MP's injuries, which quickly resulted in his death.

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