UNITED STATES AIR FORCE AIRCRAFT ACCIDENT INVESTIGATION BOARD REPORT

CV-22B, T/N 06-0032

8th Special Operations Squadron
1st Special Operations Wing
Hurlburt Field, Florida

LOCATION: Near Hurlburt Field, Florida

DATE OF ACCIDENT: 13 June 2012

BOARD PRESIDENT: Colonel Hans Ruedi Kaspar

Conducted in accordance with Air Force Instruction 51-503

EXECUTIVE SUMMARY
AIRCRAFT ACCIDENT INVESTIGATION
CV-22B, T/N 06-0032
NEAR HURLBURT FIELD, FLORIDA
13 JUNE 2012

On 13 June 2012 at approximately 2339:55 Zulu (Z) (1839:55 local time), the mishap aircraft (MA), a CV-22B, tail number 06-0032, operated by the 8th Special Operations Squadron, Hurlburt Field, Florida, impacted the ground seven minutes after take-off approximately six miles northwest of Hurlburt Field, just north of gunnery range Alpha 78 (A-78) on the Eglin Range Complex. All five members of the mishap crew sustained injuries requiring medical attention but safely exited the MA shortly after impact. The MA was destroyed upon impact with the loss valued at approximately $78,453,192.00. The MA impacted on military property, damaging several trees prior to striking the ground. Media interest was high and the accident was reported via local, national and international outlets.

The mishap sortie (MS) was a training mission flown as part of a two-ship tactical formation training line. The mishap flight (MF) consisted of the MA and the mishap lead aircraft (MLA), also a CV-22. At 2339:38Z, the MLA began a left 180-degree turn at 30 degrees of bank to bring the MF around to the southeast for the initial firing pass on A-78. During this turn, the MLA descended slightly from 366 to 336 feet mean sea level (MSL). Simultaneously, the Mishap Co-Pilot (MCP) (who was flying the MA throughout the MS) began a brief level right turn at 354 feet MSL, followed immediately by a 30-degree bank, level left turn to maintain separation from the MLA. Although this maneuver never took the MA directly behind the MLA, the MA did cross the MLA's turning flight path and the MLA's wake. As the MA crossed the MLA's flight path, the combination of the MLA's bank angle and the MA's bank angle caused the MA's left proprotor to enter the MLA's wake.

Once the MA's left proprotor entered the MLA's wake, the MA immediately began an uncommanded roll to the left. The Mishap Pilot (MP) placed his hands on the flight controls and both he and the MCP attempted to recover the MA. They were able to stabilize the MA in a wings-level flight condition but were unable to arrest the descent rate before the MA entered the 80- to 100-foot trees on the range and impacted the ground.

The MP and the MCP believed that they maintained adequate lateral and vertical separation from the MLA's flight path and therefore that the MA would remain clear of the MLA's wake. However, data from the MA and MLA flight data recorders revealed that was not the case. The MP's and the MCP's misperception was most likely caused by a combination of the MF's turning flight path and minor changes in the MLA's altitude.

The Accident Investigation Board President found by clear and convincing evidence that the cause of the mishap was the MP's and the MCP's failure to keep the MA clear of the MLA's wake. When the MA's left proprotor entered the MLA's wake, the MA's left proprotor lost lift, resulting in an uncommanded roll to the left, rapid loss of altitude and impact with the terrain. This error was due to a misperception by both the MP and the MCP of the MA's location in relation to the MLA's wake. This misperception caused the MCP, who was at the controls of the MA, to inadvertently fly the MA into the MLA's wake. This same misperception caused the MP, who was the aircraft commander, to fail to identify the hazardous situation and take appropriate corrective action either by directing the MCP to alter his position or by taking control of the MA and correcting its position to avoid the MLA's wake.

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.

SUMMARY OF FACTS AND STATEMENT OF OPINION
AIRCRAFT ACCIDENT INVESTIGATION
CV-22B, T/N 06-0032
NEAR HURLBURT FIELD, FLORIDA
13 JUNE 2012

TABLE OF CONTENTS

COMMONLY USED ACRONYMS AND ABBREVIATIONS

1 SOG	1st Special Operations Group
1 SOW	1st Special Operations Wing
23 AF	23rd Air Force
8 SOS	8th Special Operations Squadron
80/80	80 Degree Nacelle/80 Knots Calibrated Airspeed
A-78	Alpha 78
AC	Aircraft Commander
ADLS	Advanced Distributed Learning Service
ADO	Assistant Director of Operations
AF	Air Force
AFB	Air Force Base
AFE	Aircrew Flight Equipment
AFI	Air Force Instruction
AFSAS	Air Force Safety Automated System
AFSOC	Air Force Special Operations Command
AFTO	Air Force Technical Order
AFTTP	Air Force Tactics, Techniques and Procedures
AGL	Above Ground Level
AIB	Accident Investigation Board
AIE	Alternate Insertion Extraction
AR	Air Refueling
ATC	Air Traffic Control
AVI	Avionics
Bell	Bell Helicopter Textron, Inc.
Big T	Landing Zone
Boeing	Boeing Rotorcraft Systems
BP	Board President
Capt	Captain
CASEVAC	Casualty Evacuation
CDU	Control Display Unit
Chindit	Command Post
CLAMSHELL	Casualty Report
CMR	Combat Mission Ready
CMS	Cockpit Management System
Col	Colonel
Comm	Communications
CRM	Crew Resource Management
CSAR	Combat Search and Rescue
DME	Distance Measuring Equipment
DO	Director of Operations
DoD	Department of Defense
ECL	Engine Control Levers
EICAS	Engine Instrument Crew Alerting System
ELT	Emergency Locator Transmitter
EPs	Emergency Procedures
EPE	Emergency Procedure Evaluation
ER	Exceptional Release
ERC	Eglin Range Control
ETA	Estimated Time of Arrival
ETIC	Expected Time in Commission
FCF	Functional Check Flight
FCIF	Flight Crew Information File
FDR	Flight Data Recorder
FE	Flight Engineer
FL	Florida
FLIR	Forward Looking Infrared
fpm	Feet per minute
Frag	Fragmentation Order
Freque	Frequency
GPS	Global Positioning System
GRASI	Gulf Regional Airspace Strategic Initiative
HLZ	Helicopter Landing Zone
HQ	Headquarters
IAW	In Accordance With
IFAK	Individual First Aid Kit
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
IMDS	Integrated Maintenance Data System
IP	Instructor Pilot
JVX	Joint Services Advanced Vertical Lift Aircraft
KCAS	Knots Calibrated Air Speed
LPU	Life Preserving Unit
Lt Col	Lieutenant Colonel
LVA	Low Visibility Approach
LZ	Landing Zone
MA	Mishap Aircraft
Maj	Major
MAJCOM	Major Command
MC	Mishap Crew
MCP	Mishap Co-Pilot
Med-evac	Medical Evacuation
MF	Mishap Flight
MF1	Mishap Flight Engineer-Seat
MF2	Mishap Flight Engineer-Tail
MFD	Multi-Function Display
MIF	Mishap Instructor Flight Engineer
MLA	Mishap Lead Aircraft
MLC	Mishap Lead Crew
MLCP	Mishap Lead Co-Pilot
MLEF	Mishap Lead Evaluator Flight Engineer
MLIF	Mishap Lead Instructor Flight Engineer
MLF1	Mishap Lead Flight Engineer-Seat
MLF2	Mishap Lead Flight Engineer-Tail
MLP	Mishap Lead Pilot
MP	Mishap Pilot
MS	Mishap Sortie
MSL	Mean Sea Level
MSC	Mishap Squadron Commander

Nacelle	Tiltrotors
NAF	Numbered Air Force
NAVAIR	Naval Aviation
NATOPS	Naval Air Training and Operating Procedures Standardization
NM	Nautical Mile
NOTAMs	Notices to Airmen
NVG	Night Vision Goggles
OEF	Operation Enduring Freedom
OGE	Out of Ground Effect
Ops Tempo	Operations Tempo
ORM	Operational Risk Management
P'Cola	Pensacola
PHA	Physical Health Assessment
PJ	Pararescueman
PRC 112	Survival Radio
PRGB	Proprotor Gearbox
Pro Sup	Production Superintendent
Rad Alt	Radar Altimeter
Reorg	Reorganized
SA	Situational Awareness
SAIC	Science Applications International Corporation
SAR	Search and Rescue
SCIF	Sensitive Compartmentalized Information Facility
Skedco	Brand of Litter
SKL	Simple Key Loader
Spooky	AC-130U call sign
S/N	Serial Number
SOCOM	United States Special Operations Command
SOF	Special Operations Forces
SOP	Standard Operating Procedures
SSgt	Staff Sergeant
Stan/Eval	Standardization and Evaluation Section
STOL	Short Take-Off and Landing
TACAN	Tactical Air Navigation
TAGB	Tilt Access Gear Box
TCCC	Tactical Combat Casualty Care
TCL	Thrust Control Lever
TCTO	Time Compliance Technical Order
T/N	Tail Number
TO	Technical Order
TOLD	Take Off and Landing Data
TSgt	Technical Sergeant
U.S.	United States
USAF	United States Air Force
VFR	Visual Flight Rules
Vol	Volume
VTOL	Vertical Take Off and Landing
Wolf call	Eglin range ground control call sign
Z	Zulu Time

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

SUMMARY OF FACTS

1. AUTHORITY AND PURPOSE

a. Authority

On 21 June 2012, Lieutenant General Eric E. Fiel, Commander, Air Force Special Operations Command (AFSOC), appointed Colonel Hans Ruedi Kaspar as the Accident Investigation Board (AIB) President to investigate the 13 June 2012 mishap of a CV-22B Osprey aircraft, tail number (T/N) 06-0032. An AIB was conducted at Hurlburt Field, Florida (FL) from 11 July 2012 through 4 August 2012, pursuant to Air Force Instruction (AFI) 51-503. Board members were a legal advisor, pilot member, medical member, human factors member, maintenance member and recorder (Tab Y-3 to Y-5).

b. Purpose

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

2. ACCIDENT SUMMARY

On 13 June 2012 at approximately 2339:55 Zulu (Z) (1839:55 local time), the mishap aircraft (MA), a CV-22B, T/N 06-0032, operated by the 8th Special Operations Squadron (8 SOS), impacted the ground approximately six miles northwest of Hurlburt Field, just north of gunnery range Alpha 78 (A-78) on the Eglin Range Complex (Tabs D-3, K-11, S-3, AA-10 and AA-17). All five members of the mishap crew (MC) sustained injuries requiring medical attention but safely exited the MA shortly after impact (Tab X-3 to X-4). The MA was destroyed upon impact with the loss valued at approximately $78,453,192.00 (Tab P-3). The MA impacted on military property, damaging several trees prior to striking the ground (Tab S-6). Media interest was high and the accident was reported via local, national and international outlets (Tab DD-3 to DD-6).

3. BACKGROUND

The 1st Special Operations Wing (1 SOW), located at Hurlburt Field, owned the MA. The 8 SOS is assigned to the 1st Special Operations Group (1 SOG), which reports to the 1 SOW. The 1 SOW reports directly to AFSOC (Tab CC-3 to CC-15).

a. AFSOC

AFSOC is headquartered at Hurlburt Field, and is one of ten United States Air Force (USAF) major commands (MAJCOM). AFSOC's mission is to present combat ready USAF special operations forces (SOF) to conduct and support global special operations missions. AFSOC provides SOF for worldwide deployment and assignment to regional unified commands. The command's SOF are composed of highly trained, rapidly deployable Airmen, conducting global special operations missions ranging from precision application of firepower, to infiltration, exfiltration, resupply and refueling of SOF operational elements (Tab CC-3).

b. 1 SOW

The 1 SOW, located at Hurlburt Field, is one of two USAF active duty special operations flying wings and falls under AFSOC. The wing's mission focus is unconventional warfare: counter-terrorism, combat search and rescue, personnel recovery, psychological operations, aviation assitance to developing nations, "deep battlefield" resupply, interdiction and close air support (Tab CC-6).

c. 1 SOG

The 1 SOG, located at Hurlburt Field, is one of four groups assigned to the 1 SOW. The group plans, prepares and executes special operations, foreign internal defense and security assistance worldwide in support of theater commanders (Tab CC-8).

d. 8 SOS

The 8 SOS, located at Hurlburt Field, is one of nine flying squadrons in the 1 SOW. The primary mission of the 8 SOS is insertion, extraction and resupply of unconventional warfare forces and equipment into hostile or enemy controlled territory using airland or airdrop procedures (Tab CC-10).

e. CV-22 Osprey

The CV-22 is the SOF variant of the United States (U.S.) Marine Corps MV-22 Osprey. The first two test aircraft were delivered to Edwards Air Force Base (AFB), California, in September 2000. The 58th Special Operations Wing at Kirtland AFB, New Mexico, began CV-22 aircrew training with the first two production aircraft in August 2006. The first operational CV-22 was delivered to the 1 SOW in January 2007 and initial operational capability was achieved in 2009. The 27th Special Operations Wing, Cannon AFB, New Mexico, received its first CV-22 in May 2010. A total of 50 CV-22 aircraft are scheduled to be delivered by 2016 (Tab CC-16).

(1) History of the V-22 Osprey

The V-22 was developed and manufactured jointly by Bell Helicopter Textron, Inc. (Bell) and Boeing Rotorcraft Systems (Boeing) (Tab CC-19). Both Bell and Boeing have over 50 years of experience in vertical and/or short take-off and landing aircraft design. In 1956, Boeing began development of the world's first tiltwing aircraft, the VZ-2. Its maiden flight was in 1958. Concurrently, Bell's research had focused on tilting the transmissions to achieve the conversion to conventional flight. Bell's XV-3 tiltrotor successfully achieved full conversion from helicopter to airplane mode in 1958. It continued in flight test until 1966 and did much to demonstrate the feasibility of tiltrotor technology (Tab CC-22).

In the 1960s and 1970s, Boeing completed over 3,500 hours of wind tunnel testing of tiltrotor models. These models included a full-scale rotor system. Based on its experience with the XV-3, Bell was awarded a National Aeronautics and Space Administration-U.S. Army contract in 1973, to develop two XV-15 tiltrotors. Its first flight occurred in 1977 and full conversion occurred in 1979. The two XV-15s demonstrated the maturity of tiltrotor technology and were directly responsible for the birth of the Joint Services Advanced Vertical Lift Aircraft (JVX) (Tab CC-22).

Drawing upon the strengths of their respective research efforts during the preceding 30 years, the Bell-Boeing team was officially formed in April 1982. In April 1983, the U.S. Navy selected the Bell-Boeing team as the prime contractor to develop the JVX aircraft, now known as the V-22 Osprey (Tab CC-22). Bell-Boeing is specifically responsible for the design, production and sustainment of the V-22. Bell is responsible for the wing, transmissions, rotor systems, engine installation and final assembly at its completion facility in Amarillo, Texas. Boeing is responsible for the fuselage, empennage and all subsystems, digital avionics and fly-by-wire flight-control systems. The V-22's turboshaft engines are produced by the Rolls-Royce Corporation (Tab CC-19). The V-22 was approved for full-rate production in 2005 (Tab CC-22).

(2) Features of the V-22 Osprey

The V-22 Osprey is a joint service multi-role combat aircraft utilizing tiltrotor technology to combine the vertical performance of a helicopter with the speed and range of a fixed wing aircraft. With its engine nacelles and rotors in vertical position, it can take-off, land and hover like a helicopter. Once airborne, its engine nacelles can rotate to convert the aircraft to a turboprop airplane capable of high-speed, high-altitude flight. The Osprey can carry 24 combat troops, or up to 20,000 pounds of internal cargo or 15,000 pounds of external cargo, at twice the speed of a helicopter. Safety features include a cross-coupled drive system so either engine can power the rotors if one engine fails (Tab CC-18).

More than 43 percent of the V-22 airframe structure is fabricated from composite materials (See Figure 1). The composite airframe delivers the necessary stiffness and light weight for vertical take-off, as well as provides additional resistance to environmental corrosion caused by salt water. Many airframe components such as stiffeners, stringers and caps are co-cured with the skin panels. This technique provides subassemblies with fewer fasteners, thus fewer fatigue effects. Additionally, the composite airframe is fatigue resistant and damage tolerant, which is a feature particularly desirable for ballistic survivability (Tab CC-23). The V-22 design has numerous inherent and intentionally designed survivability features, including but not limited to a defense warning system, ballistic tolerance and crashworthy fuel system (Tab CC-25).

Figure 1. CV-22 Skeletal View

Two Rolls-Royce AE1107C Liberty engines provide the propulsion for the V-22. The AE1107C is a 6,150 shaft horsepower, 2-spool, turboshaft, gas-turbine engine. The engines are located within the nacelles. The interconnect driveshaft provides safe one-engine-out flight in all modes of operation (Tab CC-24).

(3) Mission of the CV-22 Osprey

The CV-22's mission is to conduct long-range infiltration, exfiltration and resupply missions for SOF (See Figure 2). This versatile aircraft offers increased speed and range over other rotary-wing aircraft, enabling AFSOC aircrews to execute long-range special operations missions. The CV-22 can perform missions that normally would require both fixed-wing and rotary-wing aircraft (Tab CC-16).

Figure 2. CV-22 Exfiltration

The CV-22 is equipped with integrated threat countermeasures, terrain-following radar, forward-looking infrared sensor and other advanced avionics systems that allow it to operate at low altitude in adverse weather conditions and medium- to high-threat environments (Tab CC-16).

The CV-22 is specifically equipped for use during special operations missions, and differs from the MV-22 primarily in its avionics and defensive systems. The following equipment is unique to the CV-22: a multi-mission advanced tactical terminal integrated with a digital map, survivor locator equipment, advanced electronic warfare suite and multi-mode radar, which permits flight at very low altitude in zero visibility and upgraded communications capability (Tab CC-26).

(4) Crew Positions in the CV-22 Osprey

The CV-22 crew consists of a pilot, a co-pilot and two flight engineers (FE) (Tab CC-17).

Pilot responsibilities include ensuring that the aircraft and equipment are thoroughly inspected in sufficient time to permit any discrepancies noted to be corrected without delaying the scheduled take-off. The pilot is also responsible for determining the aircraft's gross weight and center-of-gravity and ensuring they are within prescribed limits. The pilot is responsible for thoroughly briefing the crew on all mission particulars, as well as ensuring that the passengers have been briefed on the operational use of emergency equipment and are familiar with warning signals and emergency procedures. The pilot is responsible for ensuring that any required flight logs, records and maintenance forms are properly documented. Additionally, the pilot will ensure detailed and thorough mission planning, including engine power computations (Tab BB-26).

Co-pilot duties include assisting the pilot in mission planning by obtaining pertinent weather forecasts, intelligence reports, maps and other related documents. The co-pilot assists the pilot in performing exterior and interior inspections of the aircraft, and performs any additional inspection requirements deemed necessary by the pilot. Additionally, the co-pilot assists the pilot in operation of controls and equipment, on the ground and in the air, and operates the aircraft in flight upon instructions from the pilot. The co-pilot also prepares the flight log, required records and maintenance forms, and operates the communications and navigation equipment (Tab BB-26).

FE responsibilities include ensuring that maintenance, servicing and inspection of the aircraft have been completed prior to flight. The FE performs pre-mission/preflight duties and ensures that all mission and emergency equipment is onboard and properly stowed before each flight. Additionally, the FE performs the exterior and interior inspections, and passenger briefings as directed by the pilot. The FE monitors/operates aircraft systems, navigation, communication and mission related avionics to include defensive systems. The FE reports abnormal conditions to the pilot, and recommends and takes corrective actions, to include boldface/emergency procedures. The FE monitors fuel consumption and management, operates air refueling systems and auxiliary internal fuel systems and keeps the pilot advised of fuel status. The FE performs hoist operator, aerial gunner, cargo and/or passenger loading, litter attendant and airdrop duties. The FE also acts as a scanner, using night vision goggles (NVG), if required, and helps keep the aircraft clear of obstructions (Tab BB-26 to BB-27).

4. SEQUENCE OF EVENTS

a. Mission

The mishap sortie (MS), flown on Wednesday, 13 June 2012, was a training mission flown as part of a two-ship tactical formation training line (Tab K-11 to K-12 and K-14 to K-15). The mishap flight (MF) was scheduled to fly single-ship pilot proficiency maneuvers at Hurlburt Field, followed by day gunnery practice at A-78 and single-ship Low Visibility Approach (LVA) work at helicopter landing zones (HLZ) inside the Eglin Range Complex. The MF would refuel at Hurlburt Field and return to A-78 for night gunnery practice followed by nighttime LVA work (Tab V-6.2 to V-6.3). The MF consisted of the MA and the mishap lead aircraft (MLA). The five-person MC on the MA consisted of: the Mishap Pilot (MP), the Mishap Co-Pilot (MCP), the Mishap Flight Engineer-Seat (MF1), the Mishap Flight Engineer-Tail (MF2) and the Mishap Instructor Flight Engineer (MIF). The six-person mishap lead crew (MLC) on the MLA consisted of: the Mishap Lead Pilot (MLP), the Mishap Lead Co-Pilot (MLCP), the Mishap Lead Flight Engineer-Seat (MLF1), the Mishap Lead Flight Engineer-Tail (MLF2), the Mishap Lead Instructor Flight Engineer (MLIF) and the Mishap Lead Evaluator Flight Engineer (MLEF) (Tab K-5). The training mission was properly authorized and signed by an 8 SOS Assistant Director of Operations (ADO) (Tab K-11 to K-12 and K-14 to K-15).

b. Planning

Mission planning was detailed and the majority of it was accomplished on 12 June 2012 by the MLP and the MCP. The MLP (Squadron Operations Officer) and the MCP determined preliminary take-off and landing data (TOLD), sequence of events, route of flight and built an initial fragmentation packet (Tab V-2.2 to V-2.3 and V-6.2 to V-6.3). The MLP and the MCP arrived at a “90 percent solution” to the formation flight they would be conducting the next day (Tab V-6.2 to V-6.3). On 13 June 2012, all members of the MC and the MLC arrived by 1800Z and accomplished the remainder of the mission planning duties for their flight position in accordance with the CV-22 Standard Operating Procedures (SOP) (Tab V-6.2).

c. Preflight

On 13 June 2012, the MC and the MLC assembled to complete their mission planning duties in accordance with the CV-22 SOP, which encompassed the entire mission planning process and detailed the sequence of events for that night’s sortie (Tabs V-1.2 to V-1.3, V-6.3 and BB-10 to BB-12). The MLP conducted the preflight briefing in accordance with AFI 11-2CV-22, *CV-22 Operations Procedures*, Volume (Vol) 3, Checklist 1, covering: aircraft configuration (M240 machine gun, 1,200 rounds of ammunition and 11,000 pounds of fuel), Notices to Airmen, TOLD, weather, flight iterations, operational risk management (ORM), range briefings and all products required for the flight (Tabs F-5, K-5, K-18 to K-20, V-1.2 to V-1.3 and V-6.3). The briefing was thorough and had visual aids to accommodate all of the planned maneuvers for the flight, including traffic patterns at A-78 and contingency plans (Tabs K-10, V-1.2 to V-1.3, V-2.2 to V-2.4, V-5.2, V-6.2, V-7.2 and V-10.2 to V-10.3).

The plans for the 80-degree nacelle/80 knots calibrated airspeed (KCAS) (80/80) gun patterns followed 8 SOS Range Briefing Guide guidance and were briefed as right-hand traffic patterns with the MA staggered left and on the outside of the MLA's turns (See Figures 3 and 4) (Tabs K-10, V-1.2, V-6.2 and AA-7).

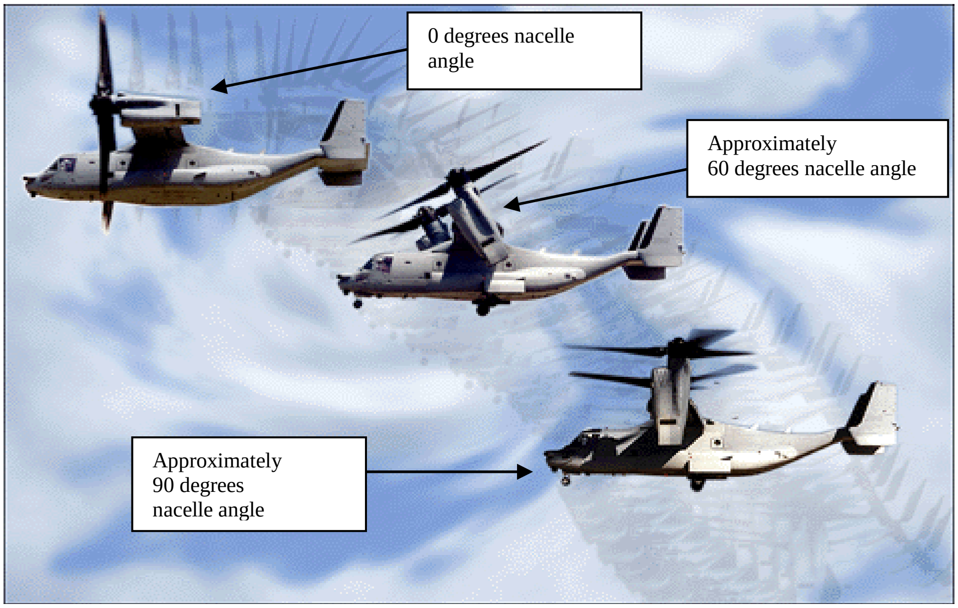

Figure 3. CV-22 Nacelle Angles

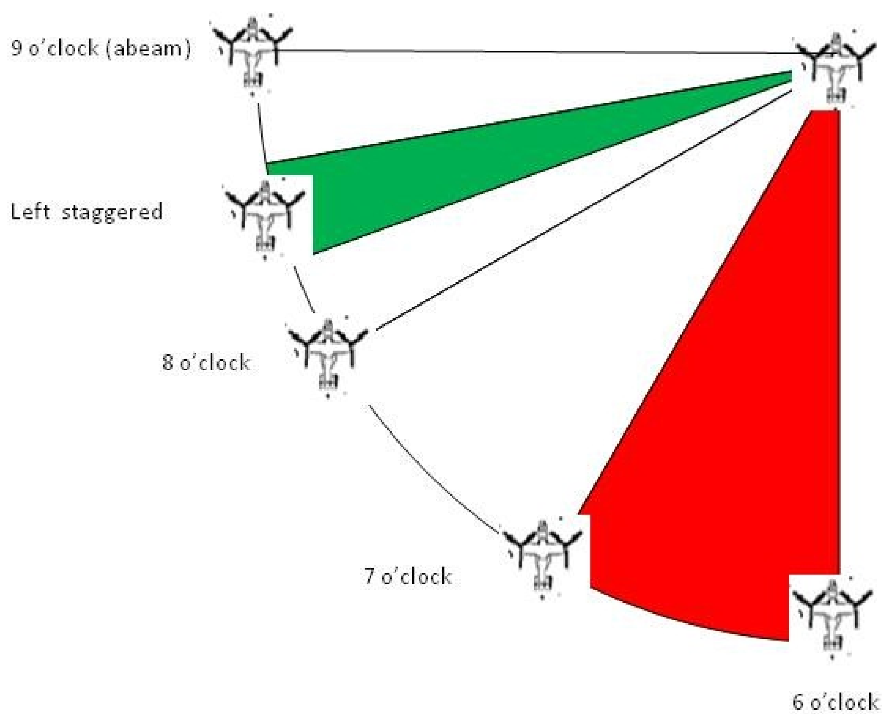

Figure 4. Clock Position in Left Staggered Formation

Following the briefing, the flight plan for the MF was filed and crewmembers completed final paperwork, including adding all pertinent data to their mission folder (Tab K-3, K-5 to K-8, K-11 to K-12, K-14 to K-16 and K-18 to K-20). When the MA was called "crew-ready," the mishap FEs stepped to the MA well ahead of schedule. Upon arrival at the MA, they discovered the MA was not crew-ready and that maintenance personnel were still working an issue with the global positioning system (GPS) (Tab V-5.3). The mishap pilots also stepped to the MA well ahead of schedule, but the GPS issue had not yet been resolved (Tab V-1.3). The MLC proceeded with the single-ship pilot proficiency maneuvers as planned and the MLP decided they would rejoin with the MC on the helicopter landing pad after the MA was crew-ready (Tab V-6.3). Once the GPS issue was resolved, the MC completed a full preflight and engine checklist in accordance with Technical Order (TO) 1V-22(C)B-1S-4. Engine start-up was normal and the MC encountered no further issues with the MA (Tab V-1.3, V-2.4 and V-5.3).

d. Summary of Accident

The MCP was the pilot flying the MA throughout the MS (Tab V-1.3 and V-2.5). The MCP taxied the MA to the helicopter landing pads on 18H/36H and rejoined with the MLA at 2326Z (Tabs K-18 and V-2.4). The MF utilized a tactical take-off and departure to the south at approximately 2332Z (Tab V-1.4 and V-2.4). After crossing the coastline, the MF initiated a turn to the west and flew parallel to the shore (Tab V-2.4 and V-6.4). The MF was directed by Eglin Approach Control to continue along the coast until they received their clearance into the Eglin Range from Eglin Range Control (ERC) (Tab V-6.4). The MF proceeded west at 1,000 feet above ground level (AGL) until they approached the Navarre Bridge, where ERC gave them clearance to enter A-78 (Tab V-1.4 and V-6.4). The briefed plan was to fly directly from Hurlburt Field to A-78 on a northwesterly heading. Instead, this direction by ERC brought the MF towards A-78 on a more northeasterly heading (See Figure 5) (Tab V-6.4).

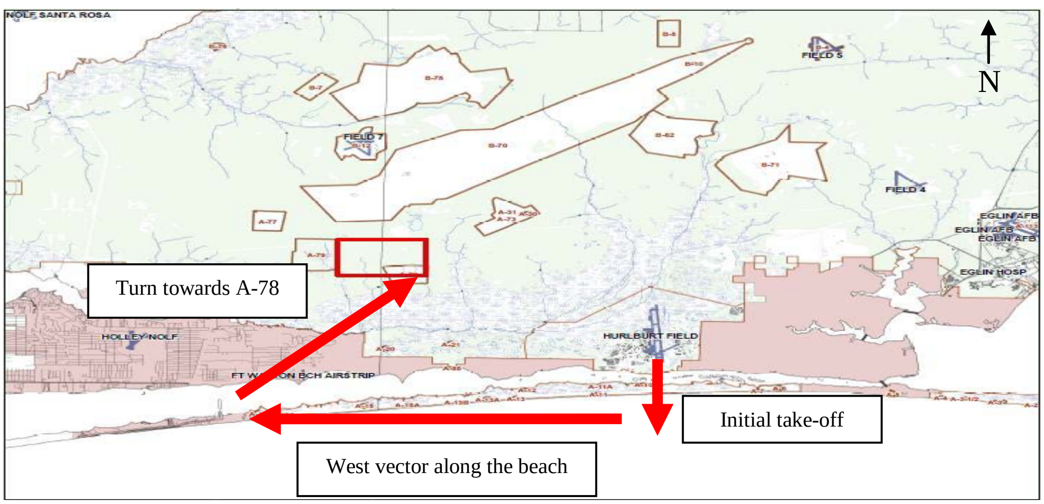

Figure 5. Actual Route of Flight to A-78

As the MF turned towards A-78, they descended to 500 feet AGL and began converting from airplane mode to helicopter mode and the briefed 80/80 flight regime into A-78 (Tabs K-10, V-1.4, V-2.5 and V-6.4).

The MLP continued on a northeast heading of approximately 030 degrees and descended the MF to 300 feet AGL (approximately 350 feet mean sea level (MSL)) (See Figure 6) (Tab AA-10 to

AA-11). The MF overflew the southeast corner of A-78 and, at 2338Z, executed a left turn at 15 degrees of bank to the northwest on a heading of 310 degrees to finish the clearing pass (See Figures 7 and 8) (Tabs V-2.6, AA-10 and AA-12). The MF confirmed A-78 was clear of all people and animals and that the MF was safe to begin live-fire operations (Tab V-9.3). Flight data gathered from the MA and MLA flight data recorders (FDR) shows that at the completion of the clearing pass, the MA was 0.2 nautical miles (NM) behind the MLA at the 7 o'clock position (aft of the MLA and 30 degrees left of the MLA's center line) (See Figure 4) (Tab AA-23).

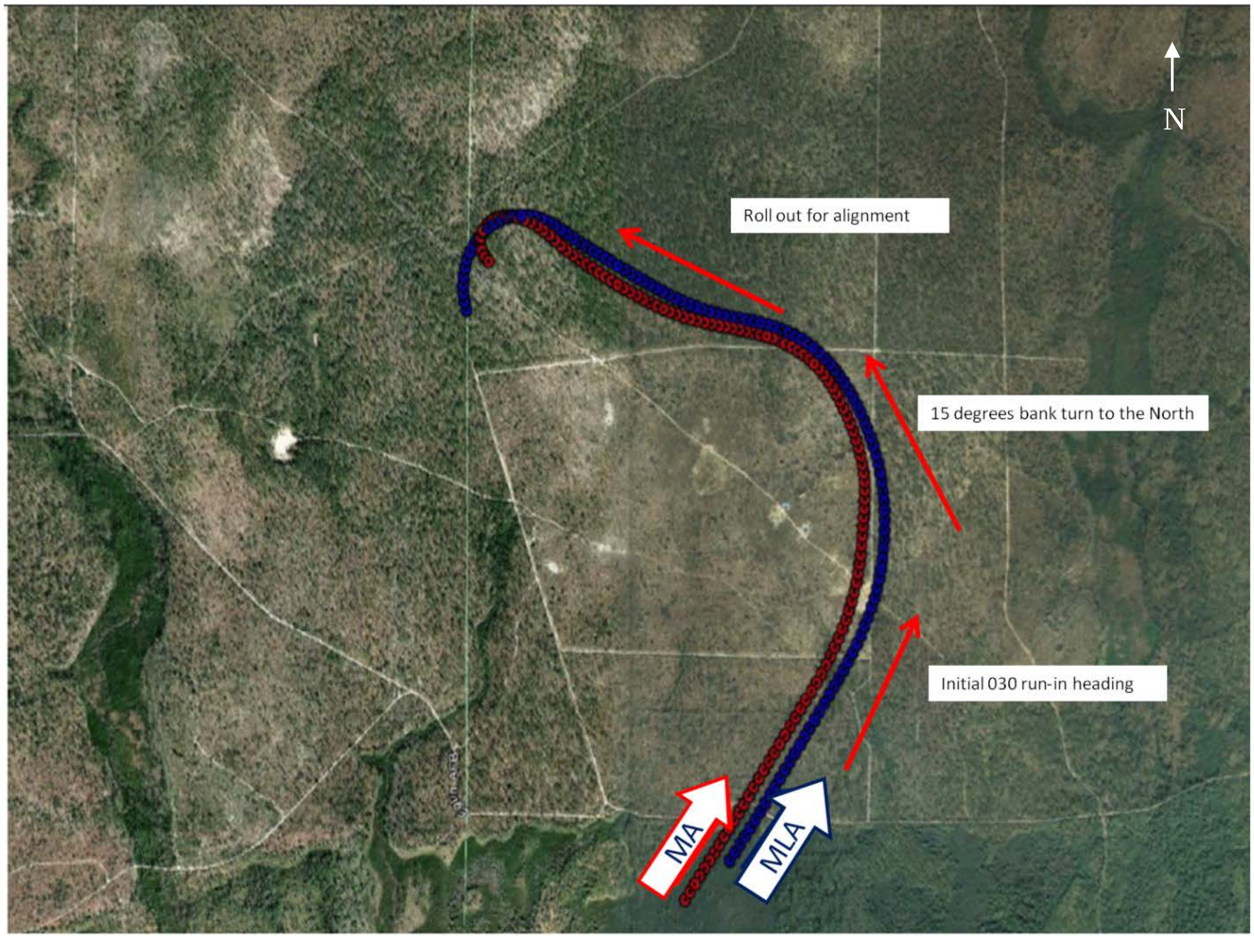

Figure 6. MF Ground Track

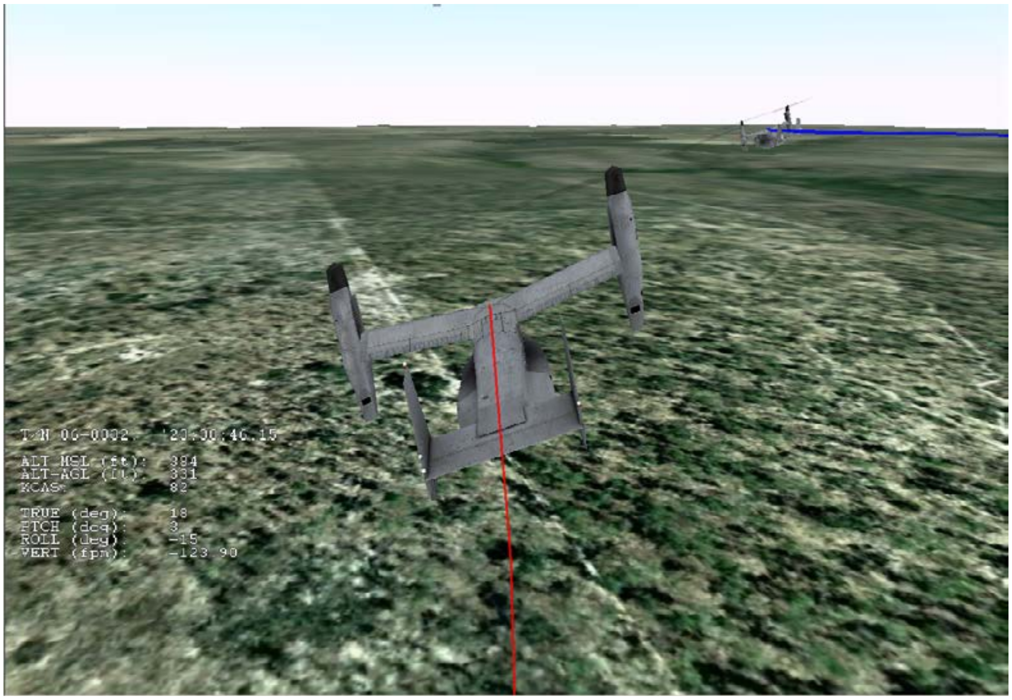

Figure 7. MF's 15-degree Angle of Bank Turn to Heading 310

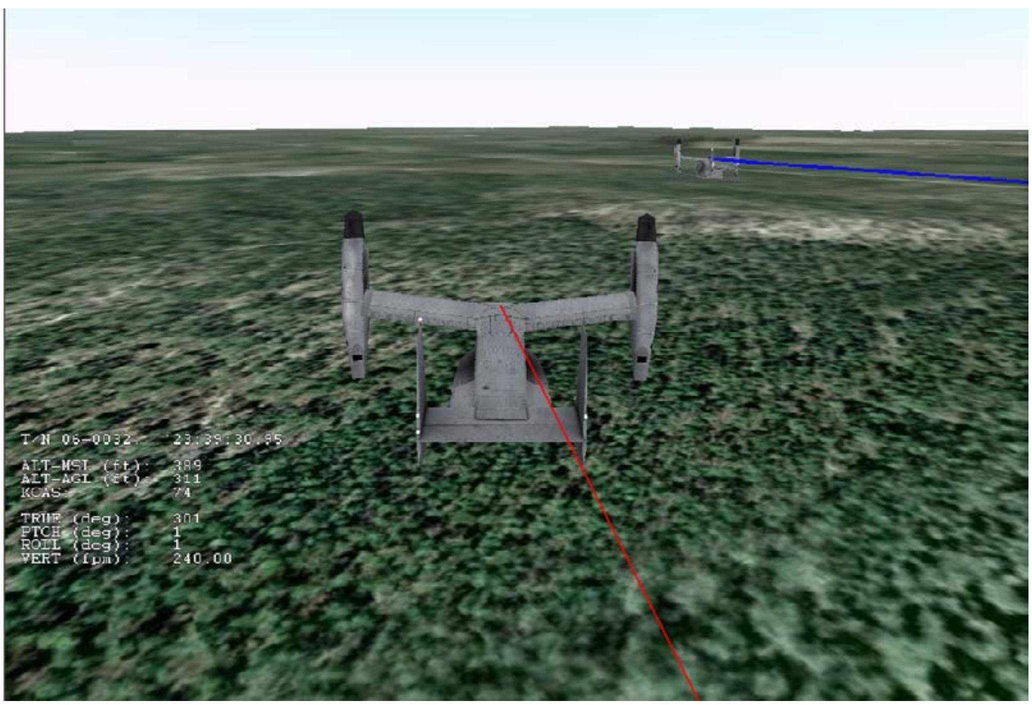

Figure 8. MF Rolls Out on Heading 310

Following the clearing pass, the MLA began a left 180-degree turn at 30 degrees of bank to bring the MF to the briefed 130 degree heading (southeast) for the initial firing pass. As the MLP began his turn, the MCP began a brief right turn to fall behind the MLA, followed immediately by a 30-degree bank, left turn to maintain separation (See Figure 9) (Tabs V-2.6, AA-10 and AA-14). Although this maneuver never took the MA to the MLA's actual 6 o'clock position, the

MA did cross the MLA's turning flight path and the MLA's wake (See Figures 10 and 11) (Tab AA-15 to AA-16).

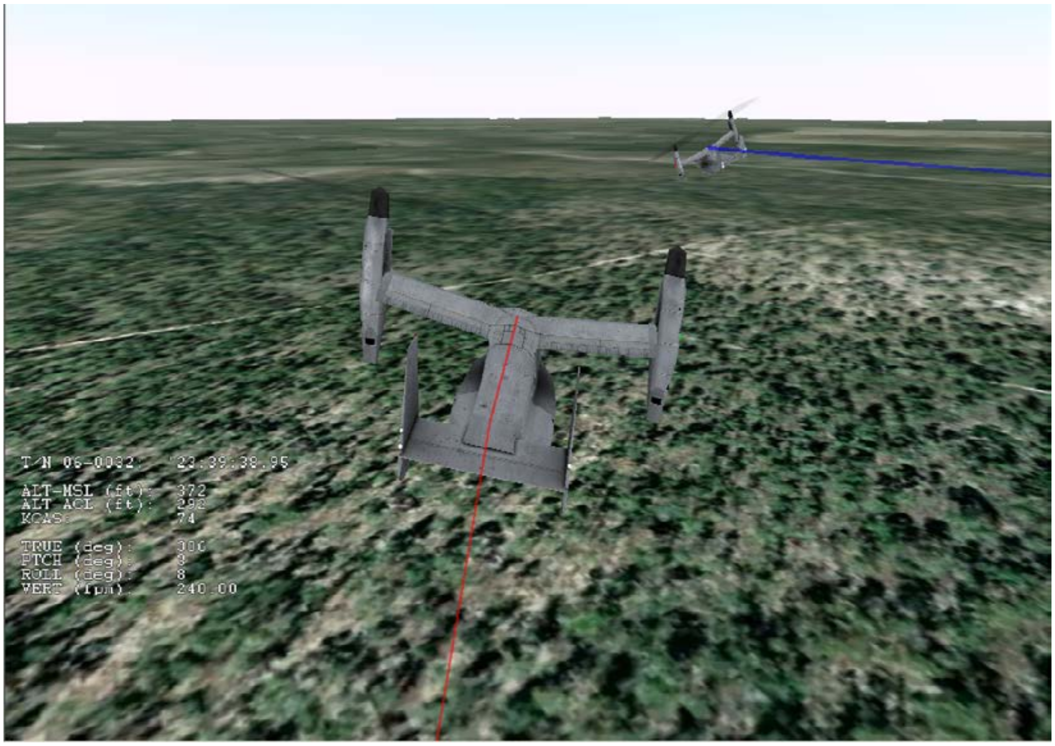

Figure 9. MA Begins Turn for Spacing

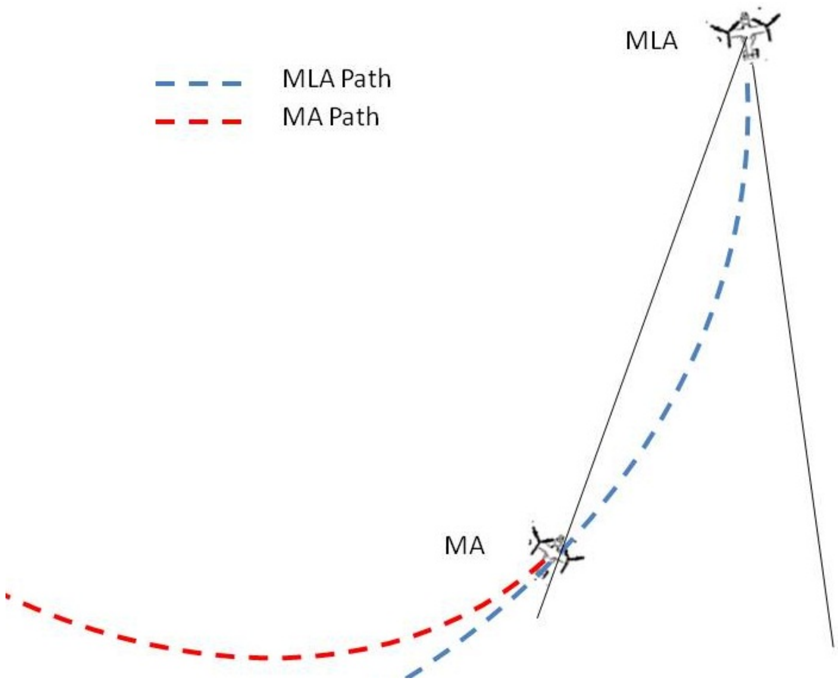

Figure 10. Turning Flightpath Versus Clock Position

At 2339:38Z, as the MLA began the left turn, the MLA was at 366 feet MSL and the MA was at 354 feet MSL (Tab AA-15 and AA-25). During the turn, the MLA descended slightly from 366 to 336 feet MSL, while the MA made a level turn (Tab AA-25). The change in the MLA's altitude gave the MCP a false impression that he had adequate vertical separation from MLA's wake (Tab V-2.7). Because the MLA was in a left bank, the MLA's right proprotor was raised above the MLA's fuselage, raising the elevation of the MLA's wake. Because the MA was also in a left bank, the MA's left proprotor dipped below the level of the MA's fuselage. As the MA crossed the MLA's flight path, the combination of the MLA's bank angle and the MA's bank angle caused the MA's left proprotor to enter the MLA's wake (See Figure 12) (Tab AA-16).

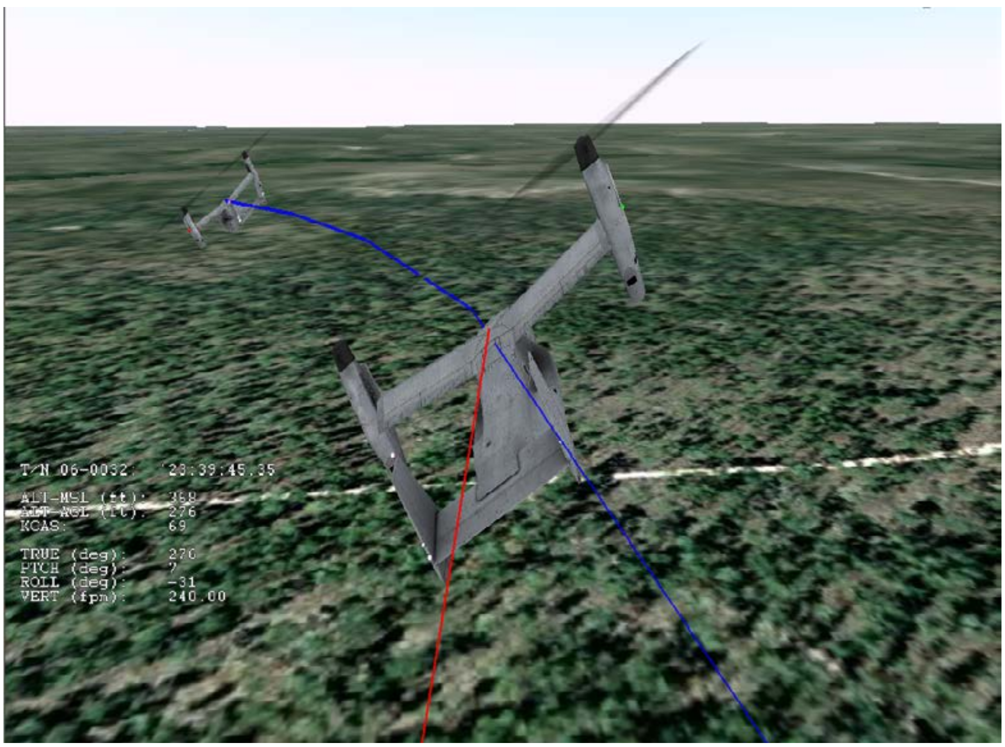

Figure 11. MA Crosses MLA's Turning Flightpath

Figure 12. MA's Left Proprotor Enters MLA's Wake

Once the MA's left proprotor entered the MLA's wake, the MA immediately began an uncommanded roll to the left reaching a maximum of 63 degrees left bank, 23 degrees nose-low attitude and 2,880 feet per minute descent (See Figures 13 and 14) (Tab AA-21 to AA-22). The MP placed his hands on the flight controls and both he and the MCP attempted to recover the MA by immediately applying full right cyclic and then full thrust control lever (TCL) (Tabs V-1.6, V-2.7 and AA-26). The MC began to regain lateral control authority of the MA after they were clear of the MLA's flight path; however, the MA was still descending at a rate of 2,600 feet per minute (Tabs V-1.6, V-2.7 and AA-22). The MC stabilized the MA in a wings-level flight condition prior to impact but was unable to arrest the descent rate before the MA entered the 80- to 100-foot trees on the range (Tabs S-6 to S-7, V-1.6 and V-2.7).

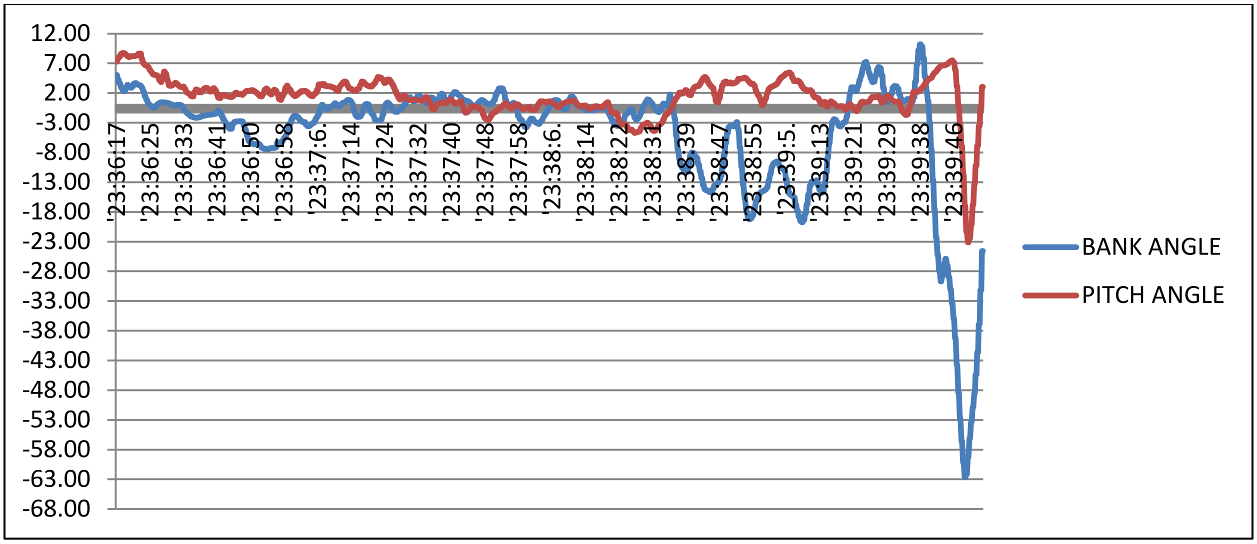

Figure 13. MA's Pitch and Bank Angle (degrees)
Note: Pitch Up is Positive, Right Bank is Positive

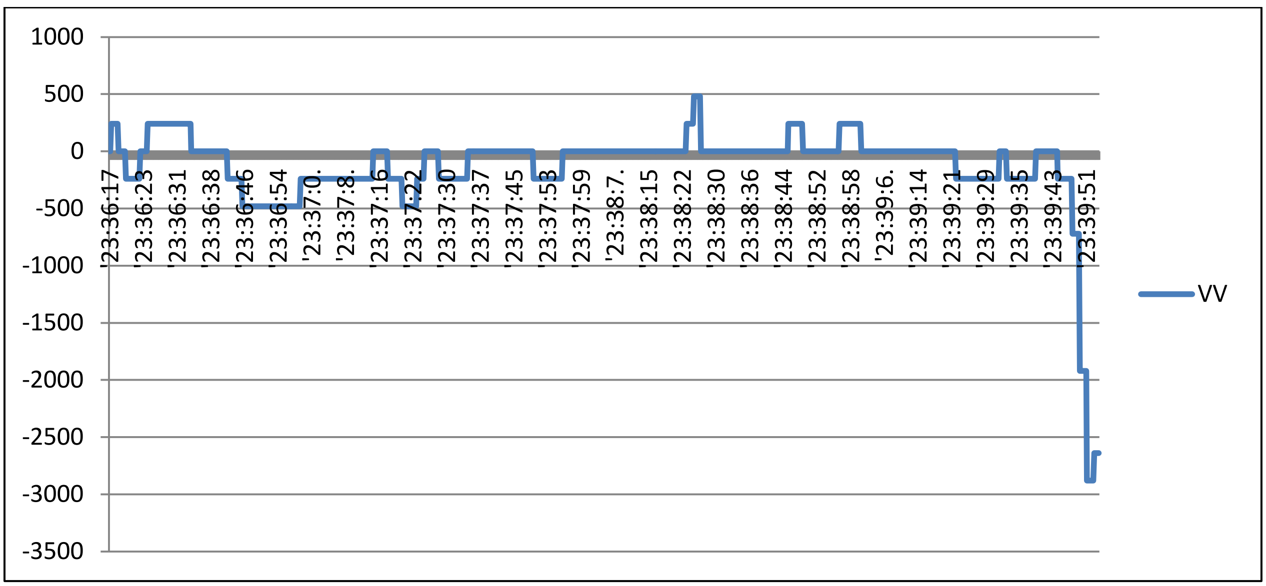

Figure 14. MA's Vertical Velocity (feet per minute)

e. Impact

The MA impacted the terrain at approximately 2339:55Z just north of A-78 in the Eglin Range (Tabs M-3 and S-3). The impact location was a sandy area, covered by 80- to 100-foot pine trees (See Figures 15 and 16) (Tab S-6 to S-7). The MA impacted the ground with the nacelles at 80 degrees and in a near wings-level and slight nose-up attitude (Tabs H-3, V-1.6 to V-1.7, V-1.9 and V-2.7). All the major components remained close to their intact/original positions on the MA (Tab H-3).

Figure 15. Crash Site from the North (Aerial View)

Figure 16. Crash Site from the Southwest

f. Egress and Aircrew Flight Equipment

Following impact with the ground, the MC was able to egress from the MA. All crashworthy systems onboard the MA operated properly, including the impact-absorbing pilots' seats and the window jettison system (Tabs H-3, V-1.15 and V-2.14). The MC's flight equipment all worked properly with no noted discrepancies (Tab V-1.15, V-2.14, V-4.6 and V-5.13).

g. Search and Rescue

Upon impact with the ground at 2339:55Z, the MA's emergency locator transmitter (ELT) sounded and was audible in the MLA. However, the MLC did not immediately realize the ELT was coming from the MA. When the MLF2 stated he could not see the MA and the MLC then saw a plume of smoke in the trees, they realized that the MA had crashed and the ELT they heard was coming from the MA (Tab V-6.5). The MLA immediately became the on-scene commander, and at approximately 2342Z, started initiating radio calls alerting agencies that the MA had crashed (Tabs M-10, V-6.4 to V-6.5 and V-7.3 to V-7.5).

The MLA circled overhead the crash site while simultaneously looking for a suitable landing site to off-load crewmembers to provide immediate assistance. Within approximately five minutes after the crash, the MLA had landed at a safe location to the southeast of the crash site and off-loaded the MLF2, the MLEF and the MLIF (Tab V-6.5 to V-6.6 and V-7.4). The MLF2, the MLEF and the MLIF ran approximately 0.5 miles to the crash site and began an initial assessment of the MC (Tab V-9.3, V-10.5 and V-11.4). Meanwhile, the remaining three members of the MLC took off and began circling overhead to provide assistance through continuing communications with the proper agencies and passing crash site coordinates and survivor status updates (Tab V-6.6 and V-7.5). During this time, the MLIF had begun using his PRC-112 survival radio to communicate with the MLA. The MLIF determined that the MCP was capable of being hoisted out for immediate transfer to a medical facility in Pensacola, FL (Tab V-10.5 to V-10.6). After the MLA landed a second time, the MLF2 joined the remaining MLC on the MLA in order to hoist out injured members (Tab V-9.4). The MLA hovered over the crash site, hoisted the MCP and began circling the crash site in airplane mode in an attempt to cool down their proprotor gearbox, which had begun heating up (Tab V-6.7 and V-7.6).

The MLIF and the MLEF continued providing care to the injured members of the MC and determined that due to the amount of downwash the MLA had produced on their previous hoist that it would be more harmful than helpful to hoist out any other injured crewmembers (Tab V-10.7 and V-11.9). The MLIF radioed to the MLA his suggestion to leave the scene and take the MCP to a medical facility in Pensacola. Although the MLIF was unable to hear any transmissions because of the overwhelming sound of the MA's ELT, the MLP and the MLCP were able to hear the MLIF loud and clear (Tab V-7.6, V-10.7 and V-11.8).

Between approximately 2359Z and 0004Z, an Eglin Range truck arrived on-scene to provide assistance (Tab V-10.7 and V-11.8). As the MLA was departing the area for Pensacola, a U.S. Army Lakota helicopter arrived on-scene and hoisted a medic down to begin providing medical care to the MC. While the Army medic provided care, a USAF Security Forces vehicle, an ambulance and fire truck arrived at the scene between approximately 0014Z and 0024Z (Tab V-10.8 and V-11.9). At that time, the MF1 was being prepared for a hoist into the Army Lakota and taken to the hospital. The MF1 was successfully hoisted after two attempts due to the lack of stability of the SKEDCO litter being used for the hoist (Tab V-10.8 and V-11.9 to V-11.10). The MF2's injuries were too substantial for a hoist, so he was transferred to a civilian medical evacuation helicopter which had landed nearby to transport him to a hospital (Tab V-11.10). The MP and the MIF were transported to the hospital by ambulance approximately 90 minutes after the crash (Tab V-1.13, V-5.12 and V-11.10).

h. Recovery of Remains

Not applicable.

5. MAINTENANCE

a. Forms Documentation

A thorough review of active and historical Air Force Technical Order (AFTO) Form 781 series aircraft maintenance forms showed that there were a total of 48 open entries contained in the MA AFTO Forms 781A and 781K (Tab U-5 to U-10). Based on the guidance in TO 00-20-1, paragraphs 4.2 to 4.4 and Figure 5.24, none of these entries were of a serious nature that would endanger safe operation of the MA.

A review of the MA historical files, to include Time Compliance Technical Order (TCTO) status, AFTO Forms 95, major inspection packages and archived data in the Integrated Maintenance Data System (IMDS) for 180 days prior to the mishap was accomplished (Tab U-3). On 1 June 2012, a recurring landing gear malfunction was corrected by replacing the landing gear control unit; however this malfunction was not related to the accident. There were no other recurring maintenance problems (Tab U-3). None of the open TCTOs in the active forms restricted the MA from flying (Tab U-3 and U-11 to U-13). There is no evidence that TCTO compliance or aircraft forms documentation were relevant to this mishap (Tab U-3).

b. Inspections

The CV-22 phase inspection cycle consists of four types of inspections (Phases A, B, C and D) performed at 210-hour intervals. These inspections can be performed up to 10 percent (21 hours) early or late to meet mission requirements, and waivers up to 20 percent can be approved by the using/lead MAJCOM (Tab BB-25). Based on this cycle, the MA was due a Phase B inspection at 1,234.7 aircraft hours (Tab U-3). This inspection was completed on 18 March 2012 at 1,201.7 aircraft hours (33 hours early as approved by the MAJCOM) (Tab U-3). The MA had approximately 100.7 hours remaining before the Phase C inspection was due (Tab D-37).

Maintenance personnel performed a preflight inspection on the MA prior to the MS (Tab U-3). The preflight inspection contains items that normally require service or verification of service prior to the first flight of the day (Tab BB-24). The preflight inspection was current as required for flight (Tab U-4). Prior to the MS, a production superintendent signed an Exceptional Release in accordance with TO 00-20-1, paragraphs 5.16.3.7.3 and 5.16.3.7.3.1, which served as a certification that the active forms were reviewed, thus ensuring the MA was safe for flight (Tab U-4). There is no evidence that MA inspections were relevant to this mishap (Tab U-3).

c. Maintenance Procedures

A review of the maintenance procedures performed on the MA revealed all required maintenance actions were in compliance with standard operating procedures. There is no evidence that maintenance procedures were relevant to this mishap (Tab U-3).

d. Maintenance Personnel and Supervision

A review of maintenance training records and historical maintenance documents revealed nothing relevant regarding maintenance personnel and supervision. All personnel were adequately trained and supervised. There is no evidence that the preflight servicing of the MA, maintenance personnel or their training and supervision were relevant to this mishap (Tab U-3).

e. Fuel, Hydraulic and Oil Inspection Analyses

Post-mishap analysis of a fuel sample from the truck that refueled the MA prior to the mishap showed all test results within normal limits. No post-mishap fluid samples were obtained from the MA. There is no evidence that MA fluids or servicing equipment were relevant to this mishap (Tab J-3).

f. Unscheduled Maintenance

A review of unscheduled maintenance actions from IMDS and historical maintenance documents for 180 days prior to the mishap was accomplished. There is no evidence that unscheduled maintenance was relevant to this mishap (Tab U-3).

6. AIRFRAME SYSTEMS

a. Condition of Structures and Systems

The post-mishap fire destroyed a majority of the fuselage and mid-wing area (Tab H-3). Additionally, both engines exhibited impact damage and thermal damage from the post-mishap fire (Tab H-5). The left- and right-hand wing sections separated from the fuselage upon impact (as designed) and remained relatively close to the impact site (See Figure 15) (Tab H-3). The MA's landing gear was in the "up" position at the time of impact (Tab V-2.17 and V-4.6). There is no evidence that MA structures or systems were a factor in this mishap (Tabs H-3 to H-5 and U-17).

b. Repair and Overhaul

At the time of the mishap, the MA's total flying time was 1,311.0 hours (Tab D-7). The MA was equipped with two Rolls-Royce model AE1107C engines. The #1 (left) engine, serial number (S/N) 130484, had 241.9 total engine and on-wing hours since being installed on 13 August 2011, with no overhauls (Tab U-14). The #2 (right) engine, S/N 130189, had 785.4 total engine hours and 77.0 on-wing hours since being installed on 6 April 2012, with an overhaul completed on 10 August 2011 (Tab U-15 to U-16). There is no evidence that repair, overhaul or testing of components and systems were relevant to this mishap (Tab U-3).

c. Engineering Evaluations

A preliminary field examination conducted by a Rolls-Royce Air Safety Investigator indicated that nothing was observed on either engine that would suggest any pre-impact engine mechanical issues (Tab H-5). Additionally, an analysis report provided by Boeing Aviation Safety indicated that the presence of cut tree tops at the mishap site indicated the proprotors were being driven by the engines at the time of the mishap (See Figure 15) (Tab H-3). No components of the MA were suspected of failure (Tabs U-17 to U-18, V-1.15, V-2.9, V-2.14, V-4.4, V-4.6 and V-5.13).

d. Functionality of Aircraft and Equipment

Data obtained from the MA FDR, reviewed by the Naval Air Systems Command V-22 Field Support Team, revealed that there were no specific indications of faults or failures in any of the MA systems (Tab U-17 to U-18). FDR data was unavailable after 2339:53Z (approximately 2 seconds before impact) (Tab AA-17). There is no evidence that the MA or relevant equipment was malfunctioning at the time of the mishap (Tabs H-3 to H-5, V-1.15, V-2.9, V-2.14, V-4.4, V-4.6 and V-5.13).

7. WEATHER

a. Forecast Weather

The 1st Special Operations Support Squadron Weather Flight provided the mission execution forecast on 13 June 2012. Surface winds at Hurlburt Field were forecast to be from the southwest at 8 knots with a temperature of 31 degrees Celsius. Anticipated visibility was 7 statute miles with few clouds at 2,500 and 5,000 feet AGL. There were no forecasted hazards for the period of flight (Tab F-5 to F-9).

Due to its close proximity, forecast weather for A-78 was identical to the Hurlburt Field forecast (Tabs F-5 and S-3).

b. Observed Weather

Raw wind data observations at the time of the mishap were similar to the forecast. The winds were light out of the southwest (Tab F-11). The MC and the MLC reported that the weather was clear, with light winds, and did not impair their mission. Post-mishap weather was described as clear with light winds (Tab V-1.7, V-2.8, V-4.3, V-6.9, V-7.8 to V-7.9, V-8.3, V-9.6, V-10.9 and V-11.5).

c. Space Environment

Not applicable.

d. Operations

Weather was within operational parameters (Tab F-11).

8. CREW QUALIFICATIONS

a. Mishap Pilot

(1) Training

The MP has been qualified in the CV-22B since 28 September 2009 and was certified as a Mission Aircraft Commander on 5 June 2012 (Tab G-6 and G-20). The MP was current for all mission-related duties at the time of the mishap (Tab T-3).

(2) Experience

The MP holds a "Senior Pilot" aeronautical rating with 2,572.5 hours of military flying time prior to the mishap (Tab G-8 and G-12). Of this total, 302 hours were in the CV-22 and MV-22 (Tab G-7). The MP previously held the position of Evaluator Pilot and had 2,270.5 hours of military flying time in the UH-1 H/N (Tab G-7 to G-8).

Recent flight time is as follows (Tab G-9 and G-18 to G-19):

	Total Hours	CV-22B	CV-22B Simulator
Last 30 Days	26.7	21.7	5.0
Last 60 Days	41.7	29.7	12.0
Last 90 Days	51.3	39.3	12.0

b. Mishap Co-Pilot

(1) Training

The MCP is a Mission Pilot and has been qualified in the CV-22B since 21 November 2011 (Tab G-34). The MCP was current for all mission-related duties at the time of the mishap (Tab T-3).

(2) Experience

The MCP holds a "Pilot" aeronautical rating with 1,608.6 hours of military flying time prior to the mishap (Tab G-25). Of this total, 92 hours were in the CV-22 and MV-22 (Tab G-24). The MCP previously held the position of Instructor Pilot and had 1,515.6 hours of military flying time in the C-130E/H (Tab G-24 to G-25).

Recent flight time is as follows (Tab G-32):

	Total Hours	CV-22B	CV-22B Simulator
Last 30 Days	7.5	4.5	3.0
Last 60 Days	9.7	6.7	3.0
Last 90 Days	14.2	11.2	3.0

c. Mishap Flight Engineer-Seat

(1) Training

The MF1 is a Mission Flight Engineer and has been qualified in the CV-22B since 5 January 2012 (Tab G-45). At the time of the mishap, the MF1 was non-current for a live hoist (using the hoist device to pull a human into the aircraft); however, this event did not preclude the MF1 from conducting any other flight duties for the MS. The MF1 was also non-current for an NVG sortie, but the MF1 would have been under the instruction of the MIF during the night portion of the MS in order to regain currency for an NVG sortie and complete his NVG gunnery instruction (Tabs K-11 and V-5.2).

(2) Experience

Prior to the mishap, the MF1 had a total of 89.0 hours of military flying time, all in the CV-22 (Tab G-37).

Recent flight time is as follows (Tab G-38 and G-44):

	Total Hours	CV-22B	CV-22B Simulator
Last 30 Days	24.4	21.4	3.0
Last 60 Days	29.3	26.3	3.0
Last 90 Days	29.3	26.3	3.0

d. Mishap Flight Engineer-Tail

(1) Training

The MF2 is a Mission Flight Engineer and has been qualified in the CV-22B since 5 August 2011 (Tab G-74). At the time of the mishap, the MF2 was non-current for an NVG sortie. However, the MIF was on the flight orders as an instructor and could have provided instruction in order for the MF2 to regain currency during the night portion of the flight (Tab K-11).

(2) Experience

Prior to the mishap, the MF2 had a total of 175.1 hours of military flying time, all in the CV-22 (Tab G-64).

Recent flight time is as follows (Tab G-72 to G-73):

	Total Hours	CV-22B	CV-22B Simulator
Last 30 Days	20.7	14.7	6.0
Last 60 Days	21.7	15.7	6.0
Last 90 Days	27.7	21.7	6.0

e. Mishap Instructor Flight Engineer

(1) Training

The MIF is a certified Instructor Flight Engineer, has been qualified in the CV-22B since 1 December 2009 and has been an instructor since 22 September 2011 (Tab G-61). The MIF was current and qualified for all mission-related duties at the time of the mishap (Tab T-3).

(2) Experience

The MIF holds a "Basic Airmen Aircrewmember" aeronautical rating with 1,987.6 hours of military flying time prior to the mishap (Tab G-48). Of this total, 516.6 hours were in the CV-22. The MIF previously held the position of Instructor Flight Engineer and had 1,471 hours of military flying time in the C-130E/H (Tab G-47).

Recent flight time is as follows (Tab G-59):

	Total Hours	CV-22B	CV-22B Simulator
Last 30 Days	28.5	15.5	13.0
Last 60 Days	28.5	15.5	13.0
Last 90 Days	35.9	22.9	13.0

9. MEDICAL

a. Qualifications

All members of the MC were medically qualified to perform flying duties at the time of the mishap. Preventative health assessments were current for all MC members. A review of the Aeromedical Information and Medical Waiver Tracking System database showed a current waiver for the MP, with no waivers for the other crewmembers. The MP, the MF1, the MF2 and the MIF had no physical or medical restrictions and were worldwide qualified at the time of the mishap. The MCP had no physical or medical restrictions but was restricted from deployment until completion of his annual dental exam (Tab X-3 to X-4).

b. Health

Hard copy and electronic medical records were reviewed for the MC. All members of the MC survived the accident and all of their injuries were attributable to the mishap. The MP suffered left upper extremity and left lower extremity injuries. The MCP suffered left upper extremity and spinal injuries. The MF1 suffered facial, left upper extremity and right lower extremity injuries. The MF2 suffered right upper and lower extremity and left lower extremity injuries. The MIF suffered a left lower extremity injury. All MC members also received various degrees of laceration and puncture injuries (Tab X-3 to X-4).

c. Pathology

Not applicable.

d. Toxicology

There is no evidence to suggest impairment due to drugs or alcohol was a factor in the mishap. Toxicology testing was conducted immediately following the mishap for all persons involved. The blood and urine samples were submitted to the Office of the Armed Forces Medical Examiner for toxicology analysis. Samples were examined for levels of carbon monoxide and ethanol in the blood and traces of any drugs in the urine to include amphetamines, barbiturates, benzodiazepines, cannabinoids, cocaine, opiates and phencyclidine. The toxicology samples arrived at the testing location in good condition. Three samples yielded positive results; the MCP, the MF1 and the MF2 had negative blood results for opioids, but positive urine tests for the same. All positive results are consistent with the administration of opiates after the mishap, which was confirmed by the medical records (Tab X-3 to X-4).

e. Lifestyle

No lifestyle factors were found to be relevant to the mishap (Tab X-3 to X-4).

f. Crew Rest and Crew Duty Time

All aircrew are required to have proper crew rest prior to performing flying duties as outlined in AFI 11-202, Vol 3, *General Flight Rules*. Proper crew rest is defined as a minimum of a 12-hour non-duty period before the designated flight duty period begins. During this time, an aircrew member may participate in meals, transportation or rest as long as he or she has had at least 10 hours of continuous restful activity with an opportunity for at least 8 hours of uninterrupted sleep. These requirements were met for all members of the MC (Tab X-3 to X-4).

10. OPERATIONS AND SUPERVISION

a. Operations

The 8 SOS has a high operations tempo including operations in support of overseas deployments, temporary duties stateside and home station taskings (Tab R-7 and R-21 to R-22). This tempo has resulted in significant challenges for the 8 SOS leadership attempting to both develop experienced crewmembers and meet operational requirements. Departure of senior aircrew members (either retiring or moving on to school), a lack of fully operational aircraft and restricted training environments in which pilots can practice LVAs or formation landings contribute to the problem (Tab R-7 to R-10 and R-20 to R-23).

The MP has been one of the squadron's ADOs since May 2012 (Tab V-1.2). Since becoming an ADO, the MP's workload had significantly decreased and he was able to focus more on flying and less on additional duties (Tab V-1.15). The MP was certified as a Mission Aircraft Commander seven days prior to the mishap (Tab G-20). The MP had flown five sorties in the two weeks prior to the mishap and flew his latest sortie on 12 June 2012, one day prior to the mishap (Tabs G-19 and V-1.2).

The MCP was a Scheduling Officer for the squadron and had been with the squadron for six months at the time of the mishap (Tab V-2.2). He had recently been deployed as a functional check flight crewmember but flew very little while deployed. He returned from his deployment on 6 May 2012, took military leave and flew only once after returning to the unit (Tabs G-32, R-18 and V-2.14). The MCP had flown only one sortie in the six weeks leading up to the mishap. The MCP flew his latest sortie on 11 June 2012, two days prior to the mishap (Tab G-32). The MS was only the second time the MCP had flown the formation gun procedures since he entered the squadron (Tab V-2.15).

The MF1 was relatively new to the squadron and flew his first flight in February 2012. At the time of the mishap, he was scheduled to deploy but was still unqualified on the M240 (Tabs G-44, T-4 and V-6.16). The MF1 had flown five sorties in the previous two weeks, with his latest sortie flown the night prior to the mishap on 12 June 2012 (Tab G-44). The MF2 had flown four sorties in the past two weeks, with his latest sortie flown the night prior to the mishap on 12 June 2012 (Tab G-73). The MIF had flown four sorties in the past two weeks, with his latest sortie flown the day prior to the mishap on 12 June 2012 (Tab G-59).

b. Supervision

The 8 SOS has an active ORM program (Tab K-14 to K-15). The MP and the MLP assessed the overall final crew risk on this mission as on the low side of medium (Tab K-14). The MIF, who was scheduled to instruct the MF1's upgrade to night guns, also served to mitigate the risk to the MC (Tab V-5.2). The highest levels of risk deemed by the MP and the MLP for this mission were: no lunar illumination, degraded radar altimeter (MLA only), requalification, upgrade and evaluation for the FEs and restricted go-arounds due to HLZ obstacles (Tab K-14 to K-15).

Supervision for the MS was provided by the Squadron Commander, the Director of Operations (MLP) and an ADO. All three levels of squadron leadership reviewed the aircrew compliments for the MC and the MLC prior to the MS (Tabs K-11 and R-17). The ORM for the formation was properly reviewed and approved (Tab K-15). Operations supervision was determined to be in accordance with AFI 11-418, *Operations Supervision*.

11. HUMAN FACTORS

The Department of Defense Human Factors Analysis and Classification System guide lists potential human factors that can play a role in aircraft mishaps. The following human factors were relevant to this mishap:

a. Misperception of Operational Conditions

Misperception of Operational Conditions is a factor when an individual misperceives or misjudges altitude, separation, speed, closure rate, road/sea conditions, aircraft/vehicle location within the performance envelope or other operational conditions and this leads to an unsafe situation.

The MCP recalled in detail the actions that he took in order to maintain position and separation from the MLA's flight path during the MS, stating that he had kept the MA outside the 5 to 7 o'clock position and stacked high in relation to the MLA while overflying A-78 (Tab V-2.7).

The MP had a similar recollection (Tab V-1.7 and V-1.17). However, analysis of the flight data recovered from the FDRs of both the MA and the MLA revealed that the MA was in fact within the 5 to 7 o'clock position of and level with the MLA's flight path (Tab AA-25). There is no evidence to suggest that either the MP or the MCP inaccurately recalled their perception of the MA's position in relation to the MLA's flight path. Comparison of the MCP's recollection with the FDR data reveals that the MCP misperceived the MA's actual relation to the MLA's flight path and controlled the MA based on that misperception. Similar comparison reveals that the MP also misperceived the MA's actual relation to the MLA's flight path.

b. Error Due to Misperception

Error due to Misperception is a factor when an individual acts or fails to act based on an illusion, misperception or disorientation state and his act or failure to act creates an unsafe situation.

Based on the precondition listed above in paragraph 11a, the MCP suffered from a misperception that the MA had both adequate lateral and vertical separation from the MLA's flight path and that the MA would therefore remain clear of the MLA's wake. The result of the MCP's misperception was the inadvertent positioning of the MA's left proprotor in the MLA's wake (Tab AA-16). The MP suffered from the same misperception. This prevented him from detecting the MA's true position in relation to the MLA's flight path and making a correction either by taking control of the MA or by directing the MCP to alter his position (Tabs V-1.22 and AA-16).

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Directives and Publications

(1) AFI 11-2CV-22, Vol 3, Checklist 1, *Flight Crew Checklist, Checklists and Signal Tables*, 9 November 2011
(2) AFI 11-202, Vol 3, *General Flight Rules*, 22 October 2010
(3) AFI 11-418, *Operations Supervision*, 15 September 2011
(4) AFI 21-101, *Aircraft and Equipment Maintenance Management*, 26 July 2010
(5) AFI 48-123, *Medical Examinations and Standards*, 24 September 2009
(6) AFI 51-503, *Aerospace Accident Investigations*, 26 May 2010
(7) AFI 91-204, *Safety Investigations and Reports,* 24 September 2008
(8) Air Force Tactics, Techniques, and Procedures 3-3.CV-22, *Combat Aircraft Fundamentals, CV-22*, Incorporating Change 1, 6 April 2012
(9) *CV-22 Standard Operating Procedures*, 1 May 2012
(10) *MV-22 Maneuver Description Guide*, Version 4.0, August 2009
(11) TO 00-20-1, *Aerospace Equipment Maintenance Inspection, Documentation, Policies, and Procedures,* 1 September 2010
(12) TO 1V-22(C)B-1S-4, *Operational Supplement, Flight Manual, USAF Series CV-22B Tiltrotor,* 29 April 2011
(13) TO 1V-22(C)B-6, *Technical Manual, Inspection Requirements Manual, USAF Series CV-22B Aircraft*, 1 May 2012

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

13. ADDITIONAL AREAS OF CONCERN

a. Lack of Emphasis on Maintaining Proper Aircraft Position in Conversion Mode Formation

The risk associated with flying formation in the conversion mode amplifies the importance of maintaining proper formation position (Tab BB-20 to BB-22). Techniques and visual references for maintaining correct clock position, distance and vertical separation for conversion mode formation with spacing from 0.0 to 0.2 NM existed in MV-22 training materials available to CV-22 crewmembers (Tab BB-32 to BB-34). Although there was no requirement to adapt these techniques for execution of formation gunnery procedures, application of these techniques may have helped the MC maintain proper aircraft position.

b. Inadequacy of CV-22 Wake Modeling

CV-22 wake modeling is inadequate for a trailing aircraft to make accurate estimations of safe separation from the preceding aircraft. Formal guidance references limited wind tunnel testing and states that the precise geometry of the V-22's wake has not been characterized in flight. It includes generalizations about wake settling along the vacated flight path of the aircraft and the severity of rotor/wake interactions being greater at slower airspeeds and higher nacelle angles but never specifies a minimum safe distance for the trailing aircraft (Tab BB-20). Specification of a minimum of 250 feet cockpit-to-cockpit separation between aircraft in formation and charts depicting aircraft wake effects extending only to 375 feet can potentially give a false sense of security to aircrews flying at significantly greater distances in trail (Tabs V-10.11, BB-15 to BB-16 and BB-22). Although the MC did not maintain the required 25 feet of vertical separation from the MLA, the MA was two- to three-times the 250 feet and 375 feet distances referenced above and still encountered the MLA's wake (Tab AA-23 and AA-25).

c. CV-22 Flight Simulator's Inability to Replicate Wake Turbulence

The CV-22 flight simulator is unable to replicate wake turbulence effects created by one CV-22 on the performance of another. Flight in the CV-22 flight simulator immediately behind and below another CV-22 operating in conversion mode demonstrates that the flight simulator does not model wake effects (Tab EE-3). As such, CV-22 crewmembers cannot experience the potentially catastrophic effects that one CV-22's wake can have on the performance of another and cannot be trained to effectively visualize and avoid that wake.

d. Lack of Corrective Procedures for Entry into CV-22 Wake Turbulence

No formal guidance exists to prescribe corrective procedures for a CV-22 that enters the wake of another CV-22. Pilots are thus left to adapt recovery procedures for entry into Vortex Ring State (which occurs when a CV-22 descends with power into its own wake) to recover from CV-22 wake entry, which may or may not be the optimal emergency action(s) (Tab BB-15, BB-20 to BB-21 and EE-4).

4 August 2012

HANS RUEDI KASPAR, Colonel, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

AIRCRAFT ACCIDENT INVESTIGATION
CV-22B, T/N 06-0032
NEAR HURLBURT FIELD, FLORIDA
13 JUNE 2012

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) and the Mishap Co-Pilot's (MCP) failure to keep the mishap aircraft (MA) clear of the mishap lead aircraft's (MLA) wake. When the MA's left proprotor entered the MLA's wake, the MA's left proprotor lost lift, resulting in an uncommanded roll to the left, rapid loss of altitude and impact with the terrain. This error was due to a misperception by both the MP and the MCP of the MA's location in relation to the MLA's wake. This misperception caused the MCP, who was at the controls of the MA, to inadvertently fly the MA into the MLA's wake. This same misperception caused the MP, who was the aircraft commander, to fail to identify the hazardous situation and take appropriate corrective action either by directing the MCP to alter his position or by taking control of the MA and correcting its position to avoid the MLA's wake.

2. DISCUSSION OF OPINION

a. Background

The mishap sortie, flown on Wednesday, 13 June 2012, was a training mission flown as part of a two-ship tactical formation training line. The mishap flight (MF) consisted of the MA, a CV-22B, tail number 06-0032, and the MLA, also a CV-22. Mission planning, briefing, ground operations and take-off were conducted without any significant difficulties. Seven minutes after take-off, at approximately 2339:55 Zulu (Z) (1839:55 local time), the MA impacted the ground approximately six miles northwest of Hurlburt Field, Florida, just north of gunnery range Alpha 78 (A-78) on the Eglin Range Complex. All five members of the mishap crew (MC) sustained injuries requiring medical attention but safely exited the MA shortly after impact. The MA was destroyed upon impact with the loss valued at approximately $78,453,192.00. The MA impacted the ground on military property, damaging several trees prior to striking the ground. Media interest was high and the accident was reported via local, national and international outlets.

b. Cause: Failure by the MA Pilots to Maintain Wake Separation from the MLA

At approximately 2336Z, while en route to A-78, the MF received clearance to enter the Eglin Range Complex and proceed directly to A-78. The Mishap Lead Pilot (MLP) turned the MF northeast to a heading of approximately 030 degrees, entered the range and descended the MF to

300 feet above ground level (AGL) (approximately 350 feet mean sea level (MSL)). The MLP overflew the southeast corner of A-78 and, at 2338Z, executed a left turn at 15 degrees of bank to the northwest on a heading of 310 degrees to accomplish the clearing pass. The MF confirmed A-78 was clear of all people and animals and that the MF was safe to begin live-fire operations. Flight data gathered from the MA and MLA flight data recorders (FDR) shows that at the completion of the clearing pass, the MA was 0.2 nautical miles (NM) behind the MLA at the 7 o'clock position (aft of the MLA and 30 degrees left of the MLA's center line).

At 2339:38Z, the MLA began a left 180-degree turn at 30 degrees of bank to bring the MF around to the briefed 130 degree heading (southeast) for the initial firing pass. During this turn, the MLA descended slightly from 366 to 336 feet MSL. Simultaneously, the MCP began a brief level right turn at 354 feet MSL to fall behind the MLA, followed immediately by a 30-degree bank, level left turn to maintain separation. Although this maneuver never took the MA to the MLA's actual 6 o'clock position, the MA did cross the MLA's turning flight path and the MLA's wake. The change in the MLA's altitude helped give the MCP a false impression that he had adequate vertical separation from the MLA's wake. However, because the MLA was in a left bank, the MLA's right proprotor was above the MLA's fuselage, raising the elevation of the MLA's wake. Because the MA was also in a left bank, the MA's left proprotor dipped below the level of the MA's fuselage. As the MA crossed the MLA's flight path, the combination of the MLA's bank angle and the MA's bank angle caused the MA's left proprotor to enter the MLA's wake.

Once the MA's left proprotor entered the MLA's wake, the MA immediately began an uncommanded roll to the left reaching a maximum of 63 degrees left bank, 23-degree nose-low attitude and 2,880 feet per minute descent. The MP placed his hands on the flight controls and both he and the MCP attempted to recover the MA by immediately applying full right cyclic and then full thrust control lever. The MC began to regain lateral control authority of the MA after they were clear of the MLA's flight path; however, the MA was still descending at a rate of 2,600 feet per minute. The MC stabilized the MA in a wings-level flight condition but was unable to arrest the descent rate before the MA entered the 80- to 100-foot trees on the range. The MA impacted the ground slightly nose-high with relatively little bank.

CV-22 formal guidance clearly directs flight crews to avoid the lead aircraft's 5 to 7 o'clock position and maintain a minimum 25-foot vertical separation when flying formation in conversion mode. Neither the MP nor the MCP recalled being inside the 7 o'clock position of the MLA or having less than adequate vertical separation. I assessed both crewmembers as being credible witnesses and have no reason to believe either has inaccurately recalled their perception of the MA's position in relation to the MLA's flight path during the MF. However, the FDR data makes it clear that the MA was in fact inside the MLA's 7 o'clock position and approximately co-altitude with the MLA.

The MP and the MCP suffered from a misperception that the MA had both adequate lateral and vertical separation from the MLA's flight path and that the MA would therefore remain clear of the MLA's wake. Their misperception was most likely caused by a combination of the MF's turning flight path and minor changes in the MLA's altitude. The result of the MCP's misperception was the inadvertent positioning of the MA's left proprotor in the MLA's wake, loss of lift, uncommanded roll to the left, loss of altitude and impact with the terrain. The result of the MP's misperception during this sequence of events was that he did not identify the change in the MA's position and take corrective action either by directing the MCP to alter his position or by taking control of the MA and correcting its position.

3. CONCLUSION

I developed my opinion based on applicable Air Force directives, consultation with technical experts, animation of the mishap sequence, witness testimony and CV-22 simulator modeling. I find by clear and convincing evidence that the cause of the mishap was the MP's and the MCP's failure to keep the MA clear of the MLA's wake. When the MA's left proprotor entered the MLA's wake, the MA's left proprotor lost lift, resulting in an uncommanded roll to the left, rapid loss of altitude and impact with the terrain. This error was due to a misperception by both the MP and the MCP of the MA's location in relation to the MLA's wake. This misperception caused the MCP, who was at the controls of the MA, to inadvertently fly the MA into the MLA's wake. This same misperception caused the MP, who was the aircraft commander, to fail to identify the hazardous situation and take appropriate corrective action either by directing the MCP to alter his position or by taking control of the MA and correcting its position to avoid the MLA's wake.

4 August 2012

HANS RUEDI KASPAR, Colonel, USAF
President, Accident Investigation Board

INDEX OF TABS
CV-22B, T/N 06-0032, Near Hurlburt Field, Florida
13 June 2012