ACTION OF THE CONVENING AUTHORITY

The report of the Accident Investigation Board, conducted under the provisions of Air Force Instruction 51-503, that investigated the 9 April 2010 mishap in Afghanistan involving an CV-22B, T/N 06-0031, assigned to the 8th Special Operations Squadron, Hurlburt Field, FL complies with applicable regulatory and statutory guidance and on that basis is approved with comment.

I find the preponderance of the evidence in this report does not support a determination of engine power loss as a substantially contributing factor. I assess the indications of engine power loss hypothesized in this report do not rise to the greater weight of credible evidence based upon the following: (1) no crew discussions, or computer generated voice warnings of an aircraft malfunction, were audible prior to impact that would corroborate that this kind of event occurred; (2) the probability of an engine failure less than two seconds prior to impact is highly remote; and, (3) this report's assessment of prop-rotor RPM at time of impact used video of the last 5.84 seconds of flight, but left 1.16 seconds unaccounted for in the analysis of the final 7 seconds of flight, leading to a seemingly inaccurate calculation of the mishap aircraft's prop rotor speed (Nr) as being abnormally low during these last moments of flight.

Kurt A. Cichowski

KURT A. CICHOWSKI
Major General, USAF
Vice Commander

04 Oct 2010
Date

UNITED STATES AIR FORCE AIRCRAFT ACCIDENT INVESTIGATION BOARD REPORT

CV-22B OSPREY, T/N 06-0031

8TH SPECIAL OPERATIONS SQUADRON
1ST SPECIAL OPERATIONS WING
HURLBURT FIELD, FLORIDA

ACCIDENT LOCATION: NEAR QALAT, AFGHANISTAN

DATE OF ACCIDENT: 9 APRIL 2010 (L)

BOARD PRESIDENT: BRIGADIER GENERAL DONALD D. HARVEL

Conducted in Accordance With Air Force Instruction 51-503

EXECUTIVE SUMMARY

AIRCRAFT ACCIDENT INVESTIGATION

CV-22B, T/N 06-0031
NEAR QALAT, AFGHANISTAN
9 APRIL 2010 (L)

On 9 April 2010, the mishap aircraft (MA), a CV-22B, T/N 06-0031, impacted the ground at 0039L, near Qalat, Afghanistan. The mishap pilot, mishap flight engineer, and two passengers died in the mishap. The mishap copilot, mishap tail scanner, and the remaining 14 passengers sustained various degrees of injuries. Based on the crash location, the deployed commanders decided the MA should be destroyed in place. The total loss for the MA, crew equipment, and ammunition totaled more than $87 million.

The MA took off as the lead aircraft of a three-ship formation from a forward operating base on a 14 minute route to a selected landing zone (LZ). The mishap crew anticipated good weather based on a regional forecast that included their main operating base. Instead, they encountered an approximately 17 knot tailwind within 10 nautical miles (nm) of the LZ. The MP flew a nonstandard approach profile to the LZ. He started the deceleration maneuver one half mile late. While converting to the helicopter mode, the MA was flying more than twice as fast as the planned profile. In the last seconds of flight, the MA developed an unanticipated rapid rate of descent and impacted the ground at 75 knots ground speed and 0.23 nm short of the intended LZ. At impact, the MA had the landing gear down and locked and the nacelle configuration was nearly vertical. The MA rolled on its landing gear across the sand for approximately 45 feet leaving landing gear marks indicative of a nearly perfect roll-on landing. Soon after touchdown, the nose gear collapsed and the nose section impacted a two-foot deep, natural drainage ditch, causing the MA to flip tail over nose. The left wing broke off and caught on fire. The right wing and tail section also separated from the fuselage, which came to rest upside down.

The Board President was unable to determine, by clear and convincing evidence, the cause of this mishap. The Board President ruled out multiple causes to include enemy action, brownout, vortex ring state, mid-air collision, loss of hydraulic system, electrical failure, drive shaft failure, swashplate actuator mount failure, flight control failure, thrust control lever (TCL) rigging, avionics failure, and crew physiological events.

The Board President determined by a preponderance of the evidence that ten factors substantially contributed to the mishap. Substantially contributing factors play an important role, either directly or indirectly, in the sequence of events and are supported by the greater weight of credible evidence. The ten substantially contributing factors were: inadequate weather planning, a poorly executed low visibility approach, a tailwind, a challenging visual environment, the mishap crew's task saturation, the mishap copilot's distraction, the mishap copilot's negative transfer from a behavior learned in a previous aircraft, the mishap crew's pressing to succeed in the first combat mission of their deployment, an unanticipated high rate of descent and engine power loss. The Flight Incident Recorder, the Vibration Structural Life and Engine Diagnostics control unit and the right engine were never recovered for analysis.

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

SUMMARY OF FACTS AND STATEMENT OF OPINION
CV-22B, T/N 06-0031 ACCIDENT
9 April 2010 (L)

TABLE OF CONTENTS

COMMONLY USED ACRONYMS AND ABBREVIATIONS

1 SOG	1st Special Operations Group
1 SOW	1st Special Operations Wing
8 SOS	8th Special Operations Squadron
A-10	A-10 Pilot
AB	Ammo Bearer
AC	Aircraft Commander
ACL	Anterior Cruciate Ligament
ACO	Airspace Control Order
ADCON	Administrative Control
ADI	Attitude Direction Indicator
ADO	Assistant Director of Operations
ADVON	Advanced Echelon
AFIT	Air Force Institute of Technology
AFPAM	Air Force Pamphlet
AFPET	Air Force Petroleum Office
AFSC	Air Force Specialty Code
AFSOC	Air Force Special Operations Command
AFB	Air Force Base
AFETS	Air Force Engineering and Technical Services
AFI	Air Force Instruction
AFTO	Air Force Technical Order
AGL	Above Ground Level
AIB	Accident Investigation Board
AIP	Aeronautical Information Publication
ALA	Assistant Legal Advisor
AMB	Air Mission Brief
AMC	Advanced Mission Computer
AMEGS	Aircraft Maintenance Event Ground Station
AMU	Aircraft Maintenance Unit
AOA	Angle of Attack
AOC	Air Operations Center
AOR	Area of Responsibility
ARMS	Aviation Resource Management System
ATC	Air Traffic Control
ATIS	Automated Terminal Information System
ATO	Air Tasking Order
BB FSR	Bell Boeing Field Support Representative
Bell	Bell Helicopter
BMNT	Beginning Morning Nautical Twilight
Boeing IDS	Boeing Integrated Defense Systems
Boeing RS	Boeing Rotorcraft Systems
BP	Board President
BPO	Basic Post-flight Operations
BSO	Battlespace Owner
C	Celsius
C2	Command and Control
CA	California
CAB	Combat Aviation Brigade
CAC	Common Access Card
CAMEO	Collaborative Automated Maintenance Environment Optimized
CAMS	Core Automated Maintenance System
CASEVAC	Casualty Evacuation
CSH/CASH	Combat Support Hospital
CC	Commander
CCP	Casualty Collection Point
CDU	Control Display Unit
CEA	A Safe Distance from Explosives
CENTCOM	Central Command
CFIT	Controlled Flight into Terrain
CG	Center of Gravity
CHK	Chalk
CHK1	Chalk 1 or Flight Lead
CHK1x	Chalk 1 Passenger
CHK2	Chalk 2
CHK2CP	Chalk 2 Copilot
CHK2FE	Chalk 2 Flight Engineer
CHK2P	Chalk 2 Pilot
CHK2TS	Chalk 2 Tail Scanner
CHK2x	Chalk 2 Passenger
CHK3	Chalk 3
CHK3CP	Chalk 3 Copilot
CHK3FE	Chalk 3 Flight Engineer
CHK3P	Chalk 3 Pilot
CHK3TS	Chalk 3 Tail Scanner
CHK3x	Chalk 3 Passenger

CJSOAC	Combined Joint Special Operations Air Component
CK	Check
CMT	Contract Maintenance Technician
CMS	Cockpit Management System
CMS	Contract Maintenance Support
CO	Commanding Officer
COMAFSOF	Commander, Air Force Special Operations Forces
Comm	Communications
CONOPS	Concept of Operations
CONUS	Continental United States
Corp	Corporation
CR	Court Reporter
CRM	Crew Resource Management
CSAR	Combat Search and Rescue
CSTARS	Center for Sustainment of Trauma and Resuscitation Skills
CT	Computerized Tomography
CTO	Compensatory Time Off
C/W	Complied With
DCC	Dedicated Crew Chief
DIRCM	Directed Infrared Countermeasures
DME	Distance Measuring Equipment
DO	Director of Operations
DoD	Department of Defense
DP	Deceleration Point
DTM	Data Transfer Module
DV	Distinguished Visitor
EAPS	Engine Air Particle Separator
EAUC	Enlisted Aircrew Undergraduate Course
ECL	Engine Control Lever
ECS	Environmental Control System
E&E	Electrical and Environmental
EICAS	Engine Instrument Crew Alerting System
ELS	Emergency Lubrication System
ELT	Emergency Locator Transmitter
EMT	Emergency Medical Technician
EP	Emergency Procedure
EPA	Evasion Plan of Action
EPP	Engine Percent Performance
ER	Exceptional Release
ERAC	Electronic Rapid Action Change
ETC	Estimated Time of Completion
EUCOM	European Command
Evac	Evacuation
Exfil	Exfiltration
FADEC	Full Authority Digital Engine Control
FAM	Familiarization
FARP	Forward Arming and Refueling Point
FAST	Failure Analysis Service Technology
FCC	Flight Control Computer
FCF	Functional Check Flight
FCIF	Flight Crew Information File
FE	Flight Engineer
FEF	Flight Evaluation Folder
FIR	Flight Incident Recorder
FL	Florida
FLIR	Forward Looking Infrared
FO	Forward Observer
FOB	Forward Operating Base
FOD	Foreign Object Debris/Damage
F(P)	Failed to Pass
FPM	Feet Per Minute
FPM	Fuel Pump Metering
FPMU	Fuel Pump Metering Unit
FPS	Feet Per Second
FRC	Fleet Readiness Center
FSO	Fire Support Officer
FSR	Field Service Representative
FST	Fleet Support Team
FST	Forward Surgical Team
FTU	Formal Training Unit
FYI	For Your Information
G	Force of Gravity
GAF	Ground Assault Force
GPS	Global Positioning System
HAF	Helicopter Assault Force
HFACS	Human Factor Analysis and Classification System
HLZ	Helicopter Landing Zone
HPW	High Performance Waveform
HQ TF CC	Headquarters Task Force Commander
HUD	Heads Up Display
IA	Imagery Analyst
IAW	In Accordance With
ICDS	Interconnecting Driveshaft

ICS	Intercommunication System
ICU	Intensive Care Unit
ICW	Intensive Care Ward
IETM	Integrated Electronic Technical Manual
IGE	In-ground Effect
ILS	Instrument Landing System
ILSMT	Integrated Logistics Support Maintenance Team
IMDS	Integrated Maintenance Data System
IN	Indiana
Inc.	Incorporated
Infil	Infiltration
INOP	Inoperable
INS	Inertial Navigation System
IP	Initial Point
IPB	Illustrated Parts Breakdown
IPS	Ice Protection System
IRCM	Infrared Countermeasures
IRS	Infrared Suppression
ISOPREP	Isolated Personnel Report
ISSC	In-Service Support Center
ISR	Intelligence Surveillance Reconnaissance
ISU	Internal Airlift/Helicopter Slingable-Container Unit
JASS	JVX Application System Software
JCN	Job Control Number
JDRS	Joint Deficiency Reporting System
JOC	Joint Operations Center
JSOAC	Joint Special Operations Air Component
JTAC	Joint Terminal Attack Controller
JVX	Joint Service Advanced Vertical Lift
KCAS	Knots Calibrated Air Speed
KGS	Knots Ground Speed
KIA	Killed in Action
KTAS	Knots True Air Speed
L	Local Time
LA	Legal Advisor
LCL	Lateral Collateral Ligament
LH	Left Hand
LLC	Limited Liability Company
LNO	Liaison Officer
LRMC	Landstuhl Regional Medical Center
LVA	Low Visibility Approach
LZ	Landing Zone
LZI	Landing Zone Illumination
MA	Mishap Aircraft
MANPADS	Man-Portable Air Defense System
MATT	Multifunction Advanced Tactical Terminal
MBITR	Multiband Inter/Intra Team Radio
MC	Mission Commander
MCP	Mishap Copilot
MCR	Mishap Crew
MD	Maryland
MEDEVAC	Medical Evacuation
MEF	Mission Execution Forecast
METAR	Meteorological Aviation Report
MFD	Multi Function Display
MFE	Mishap Flight Engineer
MGRS	Military Grid Reference System
MGT	Measured Gas Temperature
MIPC	Master Ice Protection Controller
mIRC	M Internet Relay Chat
MLG	Main Landing Gear
MM	Medical Member
MMR	Multi-Mode Radar
MO	Missouri
MOB	Main Operating Base
MOC	Maintenance Operations Center
MOS	Maintenance Operations Squadron
MP	Mishap Pilot
MRT	Maintenance Recovery Team
MSL	Mean Sea Level
MTS	Mishap Tail Scanner
MX	Maintenance
MXM	Maintenance Member
MSA	Minimum Safe Altitude
MWS	Major Weapons System
NA	Not Applicable
NAVAIR	Naval Air Systems Command
NC	North Carolina

NCOIC	Non-Commissioned Officer In-Charge
Ng	Gas Generator Speed
NLG	Nose Landing Gear
NM	New Mexico
nm	Nautical Mile
NIU	Nacelle Interface Unit
NODs	Night Optical Devices
NOTAMS	Notices to Airmen
Np	Power Turbine Speed
Nr	Proprotor Speed
NVGs	Night Vision Goggles
OBE	Overcome By Events
OCF	Operational Check Flight
OCONUS	Outside the Continental United States
OEF	Operation ENDURING FREEDOM
OEMS	Operations Emergency Medical Skills
OGE	Out of Ground Effect
OH	Ohio
OIC	Officer In Charge
OIF	Operation IRAQI FREEDOM
OPCON	Operational Control
OR	Operating Room
ORI	Operational Readiness Inspection
ORM	Operational Risk Management
OTB	Over The Beach
OTI	One Time Inspection
OTS	Officer Training School
OW	Obstacle Warning
P	Pilot
PA	Pressure Altitude
PAC	Power Assurance Check
PCA	Permanent Change of Assignment
PCS	Permanent Change of Station
PEDD	Portable Electronic Display Device
PEX	Patriot Excalibur
PFD	Primary Flight Display
PHA	Preventive Health Assessment
PM	Pilot Member
PMA-275	Program Management Authority 275
PMEL	Precision Measurement Equipment Laboratory
PMCS	Preventative Maintenance Checks and Service
P/N	Part Number
POC	Planning Operations Center
POD	Period of Darkness
PPI	Planned Position Indicator
PRGB	Proprotor Gearbox
Pro Sup	Production Superintendant
PRR	Personal Role Radio
PS&D	Plans, Scheduling, and Documentation
PTMP	Performance Trend Monitoring Program
P's & Q's	Pints and Quarts
PZ	Pick-up Zone
QA	Quality Assurance
QRC	Quick Reaction Checklist
QRF	Quick Reaction Force
RCN	Report Control Number
REC	Recorder
RFR	Ranger First Responder
RH	Right Hand
RIP	Relief in Place
RORO	Roll-On-Roll-Off
ROZ	Restricted Operating Zone
RPM	Revolutions Per Minute
RT	Receiver/Transmitter
RTB	Return to Base
RTD	Return to Duty
RTO	Radio/Telephone Operator
SA	Situational Awareness
SAAS	School of Advanced Air and Space Studies
SAQ	Statement of Airworthiness Qualification
SAR	Search and Rescue
SCP	Set Clearance Plane
SDC	Shaft Driven Compressor
SEA	Senior Enlisted Advisor
SEF	Single Engine Failure
SELO	Standardization Evaluation Liaison Officer
SEM	Senior Enlisted Manager
SIDS	Sensor Integration and Display System
SIMx	Simulator Instructor

SIRFC	Suite of Integrated Radio Frequency Countermeasures
SOAMXS	Special Operations Aircraft Maintenance Squadron
SOF	Special Operations Forces
SOFME	Special Operations Force Medical Element
SOMXG	Special Operations Maintenance Group
SOP	Standard Operating Procedure
SOS	Special Operations Squadron
SPINS	Special Instructions
STO	Short Takeoff
SIB	Safety Investigation Board
SUPTH	Specialized Undergraduate Pilot Training Helicopter
S/N	Serial Number
TACAN	Tactical Area Navigation
TAF	Terminal Area Forecast
TAR	Technical Assistance Request
TCAS	Traffic Alert and Collision Avoidance System
TCL	Thrust Control Lever
TCTO	Time Compliance Technical Orders
TDY	Temporary Duty
TF	Task Force
TF	Terrain Following
TF CC	Task Force Commander
TFR	Terrain Following Radar
TO	Technical Order
TOC	Tactical Operations Center
TOLD	Take Off and Landing Data
TOT	Time on Target
TQ	Tactical Questioning
T/N	Tail Number
TPDR	Technical Publication Deficiency Report
TST	Time Sensitive Target
TTPs	Tactics, Techniques and Procedures
TX	Texas
UPT	Undergraduate Pilot Training
USAF	United States Air Force
USMC	United States Marine Corps
USUHS	Uniformed Services University of the Health Sciences
UTE	Utilization
VLC	Very Low Clearance
VPE	Virtual Planning Environment
VR	Visual Route
VSLED	Vibration Structural Life and Engine Diagnostics
VTC	Video Teleconference
VTOL	Vertical Takeoff and Landing
VVI	Vertical Velocity Indicator
WAG	Wild Ass Guess
WCA	Warning Caution and Advisory
WIA	Wounded in Action
WRAMC	Walter Reed Army Medical Center
x2	Times 2
Z	Zulu Time

SUMMARY OF FACTS

1. AUTHORITY, PURPOSE, AND CIRCUMSTANCES

a. Authority

On 16 April 2010, Major General Kurt A. Cichowski, Vice-Commander Air Force Special Operations Command (AFSOC) appointed Brigadier General Donald D. Harvel to conduct an aircraft accident investigation of the 9 April 2010[1] crash of a CV-22B aircraft, tail number (T/N) 06-0031, near Qalat, Afghanistan. The investigation was conducted at Hurlburt Field, Florida, and Afghanistan from 26 April 2010 through 25 August 2010. Technical advisors were the Pilot Member (PM), Medical Member (MM), Legal Advisor (LA), Assistant Legal Advisor (ALA), Maintenance Member (MXM), and Recorder (REC). (Tab Y-3 thru Y-4)

b. Purpose

This aircraft accident investigation was convened under Air Force Instruction (AFI) 51-503. The primary purpose is to gather and preserve evidence for claims, litigation, and disciplinary and administrative actions. In addition to setting forth factual information concerning the accident, the board president is also required to state his opinion as to the cause of the accident or the existence of factors, if any, that substantially contributed to the accident. This investigation is separate and apart from the safety investigation, which is conducted pursuant to AFI 91-204 for the purpose of mishap prevention. The Accident Investigation Board (AIB) report is available for public dissemination under the Freedom of Information Act (5 United States Code (U.S.C.) §552) and AFI 37-131.

c. Circumstances

The accident board was convened to investigate the Class A accident involving a CV-22B aircraft, T/N 06-0031, assigned to the 8th Special Operations Squadron (SOS), 1st Special Operations Wing (SOW), Hurlburt Field, Florida, which crashed near Qalat, Afghanistan on 9 April 2010 local time (L). (Tab C-3)

2. ACCIDENT SUMMARY

On 9 April 2010, the Mishap Aircraft (MA), a CV-22B, T/N 06-0031, impacted the ground at approximately 75 knots ground speed (KGS) at approximately 0039L during a mission to infiltrate a team near Qalat, Afghanistan. (Tab C-3, Tab L-4) The Mishap Pilot (MP), Mishap Flight Engineer (MFE) and two passengers were killed in the mishap. (Tab C-3 thru C-4, Tab X-3 thru X-4) The Mishap Copilot (MCP), while still strapped into his seat, fell out of the aircraft, sustaining injuries to his spine and leg. (Tab V-1.21, Tab X-3) The flight engineer in the rear of the aircraft, serving as the Mishap Tail Scanner (MTS), suffered life threatening injuries to his arm, spine, and legs. (Tab V-60.6, Tab X-3 thru X-4) The remaining 14 passengers sustained various degrees of injuries. (Tab X-4) The aircraft was severely damaged

[1] The crash occurred at 2009 Zulu (Z) on 8 April 2010, which was 0039L on 9 April 2010 in Afghanistan.

upon impact, and then due to its location, destroyed with ordnance. (Tab V-28.33, V-38.5 thru V-38.6) The loss was valued at $87,000,000.00 for the aircraft and $142,911.36 in crew equipment and ammunition. (Tab P-3 thru P-5) Media interest following the mishap was extensive. (Tab EE-50 thru EE-63)

3. BACKGROUND

a. 1st Special Operations Wing

The 1st Special Operations Wing (1 SOW) at Hurlburt Field, Florida, is one of two Air Force active duty Special Operations wings and falls under Air Force Special Operations Command. (Tab EE-13) The 1 SOW mission focus is unconventional warfare, counter-terrorism, combat search and rescue, personnel recovery, psychological operations, aviation assistance to developing nations, "deep battlefield" resupply, interdiction and close air support. The wing has units located at Hurlburt Field, FL and Eglin Air Force Base, FL.

The wing's core missions include aerospace surface interface, agile combat support, combat aviation advisory operations, information operations, personnel recovery/recovery operations, precision aerospace fires, psychological operations dissemination, specialized aerospace mobility and specialized aerial refueling.

The 1 SOW also serves as a pivotal component of AFSOC's ability to provide and conduct special operations missions ranging from precision application of firepower to infiltration, exfiltration, resupply, and refueling of special operations force operational elements. In addition, the 1 SOW brings distinctive intelligence capabilities to the fight, including intelligence, surveillance and reconnaissance contributions, predictive analysis, and targeting expertise to joint special operations forces and combat search and rescue operations

b. 1st Special Operations Group

The 1st Special Operations Group (1 SOG), located at Hurlburt Field, FL, is one of four groups assigned to the 1st Special Operations Wing. (Tab EE-11) The group plans, prepares, and executes special operations, foreign internal defense, and security assistance worldwide in support of theater commanders.

In order to accomplish its special operations mission, the group employs more than 70 aircraft to provide day or night, all-weather access to hostile and/or denied airspace. More than 1,400 people are assigned to the group. There are ten squadrons within the group with one at a geographically separated location.

c. 8th Special Operations Squadron

The 8th Special Operations Squadron (8 SOS) is one of nine flying squadrons in the 1st Special Operations Wing, at Hurlburt Field, FL. (Tab EE-5 thru EE-10) The primary mission of the 8 SOS is insertion, extraction, and re-supply of unconventional warfare forces and equipment into hostile or enemy-controlled territory using airland or airdrop procedures. Numerous secondary missions include psychological operations, aerial reconnaissance, and helicopter air refueling. To accomplish these varied missions, the 8 SOS utilizes the CV-22 Osprey, a highly specialized Bell-Boeing tilt-rotor aircraft.

Since its inception in 1917, the 8 SOS has had more than 100 squadron commanders and flown several different types of aircraft. This list includes DH-4s, B-26s, B-57s, A-37s, MC-130Es, and CV-22s.

The 8 SOS flew the MC-130E Combat Talon until August 2006. The history of the Talon I stretched back to 1966 when the first C-130E was modified and a small squadron established at Pope Air Force Base, N.C. Later that year, four of these specially modified MC-130s were deployed to Nha Trang, Republic of Vietnam, in support of the war in Southeast Asia. During the Southeast Asia conflict, Combat Talon I's were extensively involved in covert/clandestine operations in Laos and North Vietnam. They routinely flew unarmed, single-ship missions deep into North Vietnam under the cover of darkness to carry out unconventional warfare missions in support of Military Assistance Command's Special Operations Group.

Members of the 8 SOS were deployed as part of a joint task force that landed in the Iranian desert in April 1980 in support of the American hostage rescue attempt. During that mission, five members of the squadron lost their lives. The squadron received its motto "with the guts to try" from this operation.

The squadron was called on again in October 1983 to lead the way in the rescue of American students endangered on the island of Grenada (Operation URGENT FURY). After long hours of flight, the aircrew members faced intense ground fire to airdrop Army Rangers on time and on target. They subsequently followed up with three psychological operations leaflet drops designed to encourage the Cubans to discontinue the conflict.

Members of the 8 SOS were mobilized in December 1989 as part of a joint task force for Operation JUST CAUSE in the Republic of Panama. Following the conflict, it was an 8 SOS Combat Talon I that flew General Manuel Noriega back to the United States to stand trial.

Operation DESERT SHIELD commenced in August 1990 when Iraq invaded Kuwait. The 8 SOS was deployed to Saudi Arabia as a deterrent against the Iraqi threat to its southern neighbor. In January 1991, when Iraq failed to comply with United Nations directives to withdraw from Kuwait, the proven skills of the 8 SOS were called on once again as Operation DESERT SHIELD escalated into Operation DESERT STORM. The 8 SOS played a pivotal role in the success of coalition forces as they liberated Kuwait by dropping eleven 15,000-pound BLU-82 bombs and 23 million leaflets and conducting numerous aerial refuelings of special operations helicopters.

The U.S. Air Force relies on the proven abilities of the 8 SOS as evident by its deployments in support of Operations PROVIDE PROMISE and DENY FLIGHT in Bosnia, Operation ASSURED RESPONSE in Liberia and Operation SOUTHERN WATCH in Saudi Arabia. Even Hollywood relied on the crews of the 8 SOS in the 1997 hit movie "Air Force One."

When the World Trade Center fell on September 11, 2001, the 8 SOS was propelled into Operation ENDURING FREEDOM. The squadron was nearly completely deployed, operating from several locations simultaneously to unseat the Taliban rulers and install the interim government. The 8 SOS supports operations by re-supplying SOF operators in the field, refueling helicopters, and landing at short unprepared fields all over the country. When Operation IRAQI FREEDOM kicked off, the 8 SOS was once again at the forefront. Its crews were some of the first to cross the border as hostilities began. Such a high operations tempo led to the 8 SOS being the Air Force's most deployed active duty squadron in 2002 and 2003.

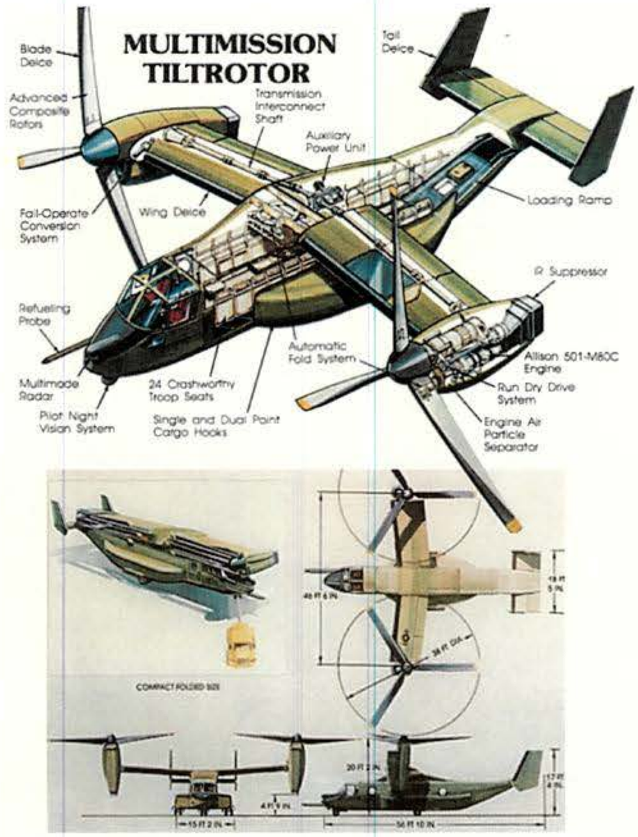
The 8 SOS CV-22s deployed in support of Operation IRAQI FREEDOM (OIF) from July to November 2009. (Tab V-2.3, V-2.6) This was the first combat deployment of the CV-22. (Tab V-28.4) The CV-22 performed infiltration, exfiltration, and logistics runs during the OIF deployment. (Tab V-7.16, V-8.5) They routinely operated at night with low lunar illumination (Tab V-2.4, V-7.10, V-28.3). The CV-22 also launched to prosecute time sensitive targets (TSTs). (Tab V-2.3) They performed simultaneous low visibility approaches with regularity during OIF. (Tab V-7.12) For OIF infiltration/exfiltration missions, CV-22 customers requested to be floor loaded with the CV-22's passenger seats removed. (Tab V-2.4, V-7.4, V-28.3) After the deployment, the 8 SOS created an 80 page standard operating procedure to be used for future flying operations. (Tab V-7.13)

d. CV-22 Osprey

The CV-22B is the Air Force modified version of the U.S. Marine Corps MV-22 Osprey. The first two test aircraft were delivered to Edwards Air Force Base, California, in September 2000 and aircrew training began at Kirtland Air Force Base, New Mexico in August 2006 with the receipt of the first four production aircraft. (Tab EE-15) The first operational CV-22 was delivered to the 1st Special Operations Wing at Hurlburt Field, Florida in January 2007. Initial operating capacity was achieved in 2009. A total of 50 CV-22 aircraft are scheduled for delivery by 2016.

(1) History and 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. (Tab EE-17) The V-22 can take off, land and hover like a helicopter. Once airborne, it converts 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. Safety features include a coupled drive system so that either engine can power the rotors if one engine fails. The V-22 design has numerous inherent and intentionally designed survivability features, including but not limited to a defense warning system, ballistic tolerance, crash worthy fuel system, and many more. (Tab EE-17)



The V-22 was developed and manufactured jointly by Bell Helicopter Textron, Inc. and Boeing Rotorcraft Systems. (Tab EE-18) The two companies combined efforts and established the V-22 joint development team known as Bell-Boeing. Bell-Boeing is specifically responsible for the design, production, and sustainment of the V-22. The V-22's turboshaft engines are produced by Rolls-Royce Corporation, a subsidiary of Rolls-Royce North America, Inc. (Tab EE-18)

(2) Mission and Features of the CV-22 Osprey

The CV-22 is an Air Force Special Operations platform. Its versatility as a fixed-wing and rotary-wing aircraft, its long range (up to 500 nautical miles combat mission radius) and high cruising speed, make the CV-22 the perfect choice for Air Force special operations to conduct long-range infiltration, exfiltration and resupply missions. (Tab EE-15 thru EE-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. Equipment unique to the CV-22 includes a multi-mission advanced tactical terminal integrated with a digital map, survivor locator equipment, and an advanced electronic warfare suite, multi-mode radar which permits flight at very low altitude in zero visibility, and upgraded communications. (Tab EE-23)

(3) Crew Positions in the CV-22

The CV-22 consists of a crew of four; a pilot, a copilot, and two flight engineers. In the CV-22, the pilot and copilot are qualified to fly in either seat of the aircraft. (Tab V-1.4) Standard responses during crew communication are "copilot" for the left seat pilot, "pilot" for right seat pilot, "FE" for flight engineer in the cockpit and "tail" for the flight engineer in the tail scanner position. These responses are used when running checklists as well. (Tab V-7.32) The flight engineer in the cockpit is responsible for running checklists, mission management, and overall health of the aircraft to include executing emergency procedures. (Tab V-12.2, V-13.2, V-17.2) The flight engineer is also responsible for calculating the power required based on atmospheric conditions as well as computing and managing weight and balance of the aircraft and its cargo and passengers. (Tab V-12.2, V-13.2, V-17.2) The tail scanner is at the rear of the aircraft where they serve as a loadmaster, hoist-operator, scanner and gunner for the .50 caliber gun mounted on the ramp. (Tab V-12.2, V-13.2, V-17.2) All CV-22 flight engineers are trained for both positions in the aircraft and based upon crew preference, alternate positions at the front and rear of the aircraft on a regular basis. (Tab V-13.9, V-18.3)

e. Companies and Organizations Supporting the CV-22 Project

(1) Bell Helicopter, Textron Inc. (Fort Worth, TX)

Bell Helicopter (Bell), a wholly owned subsidiary of Textron Inc., is headquartered in Fort Worth, TX. The company is known as a leading manufacturer of military helicopter and tiltrotor products and as a premier provider of commercial rotorcraft products. (Tab EE-47) Bell's research and development of tiltrotor technology dates back to 1954. (Tab EE-25) In April 1982, Bell teamed up with Boeing Rotorcraft Systems to form the Bell-Boeing team, which ultimately designed and developed the V-22 Osprey. (Tab EE-23 thru EE-45) Bell's responsibility over the CV-22 consists of manufacturing and integrating the wing, transmissions, empennage, and rotor systems, as well as integrating the aircraft's Rolls-Royce engines. (Tab EE-19)

(2) Boeing Rotorcraft Systems (St. Louis, MO)

Boeing Rotorcraft Systems (Boeing RS) is part of Boeing Integrated Defense Systems (Boeing IDS), a unit of the Boeing Company, headquartered in St. Louis, Missouri (MO). Boeing IDS specializes in defense and aerospace products and services and is one of the largest manufacturers of military aircraft. (Tab EE-18) As a subdivision of Boeing IDS, Boeing RS is involved in designing, developing and manufacturing transport and

combat helicopters and tiltrotor aircraft. Boeing RS products include the AH-64 Apache, the CH-47 Chinook, and the V-22 Osprey. (Tab EE-18)
Boeing RS first started its development of tiltwing aircraft in 1956 and continued its testing on tiltrotor models into the 1960s and 1970s. Boeing RS is a major player in the design and development of the V-22 as part of the Bell-Boeing team. Boeing RS specifically manufactures and integrates the fuselage, cockpit, avionics, and flight-control systems of the CV-22. (Tab EE-15 thru EE-16)

(3) Rolls-Royce Corporation (Indianapolis, IN)

Rolls-Royce Corporation (Rolls-Royce Corp.), headquartered in Indianapolis, Indiana (IN), is a subsidiary of Rolls-Royce North America, Inc. Rolls-Royce Corp. is involved in designing and manufacturing aircraft, industrial, and marine engines. (Tab EE-49) It holds the largest Rolls-Royce manufacturing site in North America, where all aspects of turbine engine and component design, development, testing, and production takes place. The Rolls-Royce Corp. manufactures the AE1107C Liberty turbo-shaft engines, which provide the propulsion for the V-22. (Tab EE-49)

(4) Naval Air Systems Command (Patuxent River, MD)

The Naval Air Systems Command (NAVAIR) is a United States Navy command, headquartered in Patuxent River, Maryland (MD). NAVAIR employs military and civilian personnel stationed throughout the United States who provide unique engineering, development, testing, evaluation, in-service support, and program management capabilities for naval and joint program aircraft and airborne weapon systems. (Tab EE-15)

The CV-22 program is managed by a NAVAIR component, the Navy V-22 Joint Program Office, Program Management Authority 275 (PMA-275), which was established to oversee and ensure the integration of the V-22 with special operations capabilities and improvements. PMA-275 is staffed by acquisition professionals from the Marine Corps, the Navy and the Air Force, who support the unique mission requirements and capabilities of both the MV-22 and CV-22 programs. (Tab EE-15)

4. SEQUENCE OF EVENTS

a. Pre-deployment Training, Preparation, and Staging

The 8 SOS began a pre-deployment training program after returning from its OIF deployment in November 2009. (Tab V-2.6 thru V-2.7) This included two exercises to locations in the southwest United States in January and February 2010, which were specifically focused on working with the teams projected to deploy with them during OEF, and to build skills on missions and the environment expected in the Area of Responsibility (AOR). (Tab V-1.15, V-2.7, V-7.13, V-67.19) All training objectives were achieved. (Tab V-2.8, V-7.8, V-7.12, V-7.13) In March 2010, the aircraft were flown to Corpus Christi, TX and placed on a ship for transport to the AOR. (Tab V-2.7) Once the aircraft were placed on the ship, the unit completed its training by flying two or three simulator sorties per crew. (Tab V-2.8) During this time, the squadron also finalized hard crews that would fly together during the deployment. Each hard crew trained on the new avionics software and heads up display (HUD), and rehearsed mission scenarios using the simulator database of the AOR. (Tab V-28.24, V-60.16) This simulator time also served to build crew cohesion and enhance their teamwork. Specific training hours for the Mishap Crew (MCR) are discussed in Section 8 below.

The remainder of the time between November 2009 and March 2010, when the unit deployed, was spent preparing for deployment, completing required aircrew currency training events, and providing squadron members with personal time. (Tab V-2.6 thru V-2.7)

The squadron's aircraft arrived in the AOR and maintenance personnel offloaded them from the ship at a port on 30 March 2010. (Tab V-25.2, V-25.9) The aircrews met the aircraft there, and performed brief operational check flights, followed by an approximately six-hour ferry flight to the Main Operating Base 1 (MOB1) in Afghanistan. (Tab V-2.7) After spending several days loading new avionics software, the aircraft were ready to fly.[2] (Tab V-2.9, V-2.22, V-25.9) The squadron then executed a program to become familiar with the local area prior to flying missions. (Tab V-28.29) This was planned as a two-hour sortie per crew, focusing on flying to different forward operating bases (FOBs), conducting aerial gunnery, and practicing low visibility approaches (LVAs). (Tab V-7.6, V-28.29)

The MFE and MTS flew with other crews on the 1 April 2010 ferry flights. (Tab AA-3 thru AA-36) Members of the MCR flew a familiarization sortie on 5 April 2010 (not as a hard crew); a familiarization sortie on 6 April 2010 (as a hard crew) and a distinguished visitor (DV) support sortie on 7 April 2010 (as a hard crew). The crews, including the MCR, completed all training and familiarization objectives. (Tab V-28.29)

b. Mission

The mission was a routine infiltration in support of ground forces in Afghanistan. (Tab V-13.3, V-15.3, V-18.3) It was tasked and approved by higher headquarters through normal channels and processes on 8 April 2010. (Tab K-4 thru K-5, Tab V-29.3) It encompassed flying to a FOB, picking up a team, and flying to the infiltration site. (Tab V-10.3, V-10.9, V-28.29) It consisted of a three ship formation of which the MCR was flight lead (Chalk 1). His wingmen were Chalk 2 and Chalk 3.

c. Planning and Briefing

The three mission crews showed at 1445Z. (Tab V-10.10, V-67.1) The aircraft commanders then attended a 1515Z alert assumption briefing. (Tab V-7.30 thru V-7.31, V-10.10, V-28.41 thru V-28.42, V-67.1) Mission planning was adequate and fully supervised by the mission

---

[2] The Avionics software loading plan changed from loading at the port to loading at MOB1. Operations planned for the load at the port, while maintenance planned to load at MOB1. Sometime during late March 2010, MC realized that he had to accept the maintenance plan instead of the operations plan.

commander (MC). (Tab V-7.30, V-10.10, V-28.41 thru V-28.42) The squadron was on an alert posture that resulted in being tasked for a short-notice mission with a compressed timeline for mission planning. (Tab V-1.17, V-2.3, V-7.11, V-10.10, V-67.1) The MP was scheduled as the flight lead for the 8 April 2010 mission. (Tab V-28.29) His duties included the responsibility for planning and briefing the mission. (Tab V-10.29, V-28.29) He received the mission information around 1515Z and began planning, with the assistance of the other two aircraft commanders, in accordance with (IAW) squadron standard operating procedures (SOPs). (Tab V-10.10) The majority of this planning focused on identifying landing zones (LZs) that would work for both the team and the aircraft. (Tab V-2.23) This was done with the assistance of an Imagery Analyst (IA). (Tab V-1.4, V-2.23, V-36.5) During the planning period, MP also determined the landing zone illumination (LZI) plan so that it could be disseminated to supporting air assets. (Tab V-31.3, V-47.2) This planning included coordination with all mission players through the CV-22 liaison officer (CV-22 LNO) at the Joint Operations Center (JOC). (Tab V-29.3)

Prior to stepping to the aircraft, flight engineers computed weight and balance and take off and landing data (TOLD). (Tab K-8) This data was updated following the Air Mission Brief (AMB) at the Forward Operating Base (FOB) with the latest mission information from the passengers. (Tab V-17.3) The MA's take off gross weight was 45,485 lbs, which resulted in out of ground effect (OGE) plus five percent. (Tab K-6) This would allow a 50 foot hover with an extra five percent power margin. The maximum single engine altitude for 60 nacelle was 5,200 feet mean sea level (MSL), just below the elevation of the LZ. (Tab 13.6) In airplane mode, the maximum single engine altitude was 10,400 feet MSL. On the night of the mishap, the only power margin required was OGE hover power. (Tab V-28.14) Single engine capability was not a go/no-go requirement. (Tab V-46.21 thru V-46.22)

The squadron's weather planning strategy was developed from the supported task force's existing weather support plan. (Tab V-28.30) The task force did not have a weather person at MOB1 – instead the weather forecaster was stationed at another main operating base (MOB2) in country. (Tab V-28.30) The flight crews received a one page weather "flimsy" from that forecaster via email. (Tab F-3, V-62.3, V-67.2) This flimsy allowed the crew to look up some of the observations from outlying automated stations in the area via the internet. (Tab V-15.22) The forecaster was also available by phone for additional information. (Tab V-28.30) When the 8 SOS arrived in country, neither the planners, the flight crews nor the MC pursued using any of the numerous weather sources available at MOB1. (Tab V-2.5, V-28.4) The unit only briefly discussed weather phenomena in the country with other helicopter assets as part of the local area familiarization. (Tab V-22.23, V-28.25) A large contingent of U.S. helicopters operates at that location, and they have very detailed weather support for all the operating locations in the region. (Tab V-28.30, Tab W-3 thru W-32)

On the mishap night the weather brief only comprised the weather flimsy, which provided weather data for MOB1. (Tab F-3) No FOB observations were available or received, according to the aircrews. (Tab V-28.30) Because this forecast called for good weather, and the mission location was within 60 miles, the aircrews assumed that weather would not be a factor. (Tab V-10.4, V-15.3) The winds at the mishap site were significantly different from MOB1 and what was expected by the MCR. (Tab V-13.11) However, winds at the mishap site were exactly as predicted according to the forecasted weather from the nearby FOB Wolverine. (Tab F-5, Tab W-12 thru W-17)

The aircraft commanders conducted the mission briefing in the squadron's Planning Operations Center (POC), using standard briefing checklists. (Tab V-10.11, V-28.12) MC was present during the planning and the briefing. (Tab V-28.12) This briefing was shortened by the use of the squadron's SOP, so that only deviations from the SOP were briefed. (Tab V-7.30) That allowed for the briefing to focus on the LZ operations. (Tab V-8.13) The MC provided his guidance for the mission as well as his assessment of the risk and appropriate mitigation. (Tab V-7.30, V-28.41 thru V-28.42) Notices to Airmen (NOTAMS), weather, take off and landing data (TOLD), operational risk management (ORM), and flight plans were gathered, analyzed, calculated, and briefed. (Tab V-10.20 thru V-10.21, V-62.4)

While the aircraft commanders planned the mission, the copilots and flight engineers went out to the aircraft to accomplish the preflight and before start checklists in order to expedite the alert launch process. (Tab V-28.12) The MP briefed his crew at the aircraft on the mission specifics prior to launching out of MOB1. (Tab V-1.3 thru V-1.4) Once the aircraft arrived at the FOB, the aircraft commanders and lead flight engineers conducted an air mission brief (AMB), a face to face briefing, with the team. (Tab V-20.11, V-67.3) At this briefing, only minor changes to the timeline were made and the objective and LZs were confirmed. (Tab V-10.11, V-15.4) The MP briefed his crew members on the final plan at the aircraft prior to taking off. (Tab V-1.4) The mishap crew, as well as the other mission crews, fully understood the mission specifics as briefed that night. (Tab V-10.4, V-10.10, V-28.34)

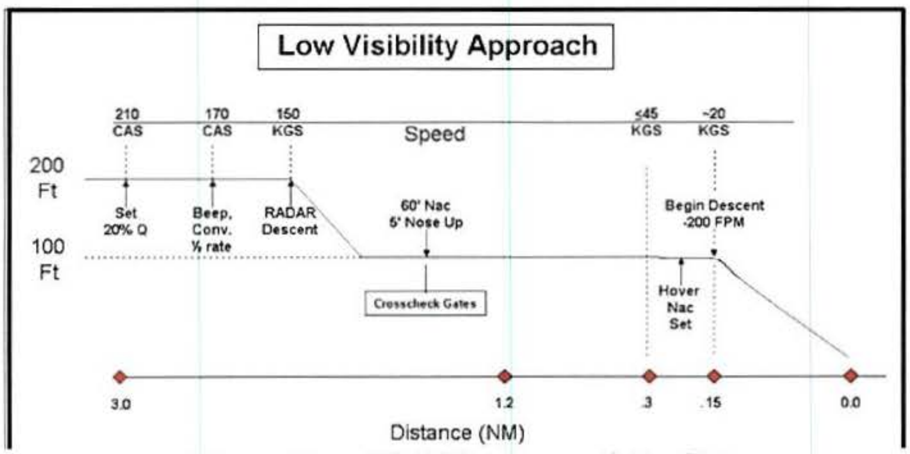
d. Preflight and Taxi

The only notable event during preflight was a hung start on the MA's right engine, which required no additional maintenance actions. (Tab V-56.12, Tab GG-35) The engine started normally on the second attempt. The flight taxied out to the parallel taxiway for a northeasterly takeoff. (Tab V-56.12, Tab JJ-3 thru JJ-4)

e. Flight

On 8 April 2010 at 1805Z, the MA took off as the lead aircraft of a three-ship formation from MOB1. (Tab AA-9, Tab JJ-3 thru JJ-4) The formation landed at the FOB at 1835Z after an uneventful flight. (Tab V-60.3, Tab AA-9) The time on the ground was sufficient to conduct briefings, reconfirm mission data, load and configure the aircraft for the mission without being rushed. (Tab V-10.11, V-11.11, V-15.15, V-18.3, V-60.3, V-67.21) Following the AMB at the FOB with other tasked mission personnel, 16 personnel boarded and secured themselves in the MA. (Tab K-6 thru K-8, Tab X-3 thru X-5) The remaining 32 personnel boarded Chalks 2 and 3. The MA departed at 1956Z, leading the formation, with the MCP at the controls. (Tab L-4, Tab V-1.5, V-67.4, Tab AA-9) The take off was an 80 jump maneuver to the northwest. (Tab V-67.4) The MCP applied maximum power and felt the aircraft was heavy. (Tab V-67.4) Several passengers commented that the take off and climb were unstable. (Tab V-6.4) The MCR began their planned 14 minute route to the LZ. (Tab V-10.4) The formation climbed to approximately 8,000 feet MSL and leveled off. (Tab V-67.4) The MA's climb was steep. (Tab V-6.4, V-21.2, V-64.6) After leveling off, the MP took over the aircraft controls. (Tab V-67.4)

The en route portion of the flight was uneventful except for the typical radio communication problems common to the CV-22 aircraft. (Tab R-59, Tab V-10.3, V-25.4) As the formation departed, the MP coordinated a new time on target (TOT) with the other flying assets and the appropriate controlling agencies on the ground. (Tab II-15) The MCR flew at a lower speed than the planned cruise speed of 220 KCAS (240 KGS). For the first ten minutes of the flight, the MA's speed was 20 to 30 knots below the maximum attainable speed with the new avionics software. (Tab L-4, Tab V-15.6, Tab II-6, Tab JJ-3 thru JJ-4, JJ-5, JJ-51 thru JJ-52) The MP descended the formation to low-level altitude starting at 2002Z using the Terrain Following (TF) radar. (Tab JJ-3) While descending, the MP made a radio call to the formation, "500" to inform the formation to set 500 feet as the set clearance plane. (Tab V-10.5) The MA crossed the initial point (IP), 10 nm from the LZ, at 600 feet AGL and 235 KCAS (266 KGS). (Tab L-4, Tab JJ-4) The MP made a "two minute" radio call to signal other assets to initiate the LZI plan at 20:08:07. (Tab II-15) The A-10 and intelligence, surveillance, and reconnaissance (ISR) assets initiated the planned LZI at that time. (Tab II-15) The MCP observed two illumination beams when he only expected one. (Tab V-1.24, V-67.5) As they continued their descent to the deceleration point (DP), the MCR deactivated the TF radar mode and set the radar altimeter low setting to 80 feet. (Tab V-1.8)



(Normal Low Visibility Approach Profile)

At the DP, 3 nm from the LZ, the winds were 060 degrees at approximately 17 to 20 knots. (Tab V-10.18, V-10.26, V-11.5, V-11.6, V-13.25, V-15.7 thru V-15.8, V-16.4, V-17.6, Tab Z-27, Tab GG-3, Tab II-12) The MA crossed the DP at approximately 300 feet AGL and 230 KCAS (270 KGS). (Tab JJ-3 thru JJ-4) The MP started the deceleration maneuver one half mile late, at 2.5 nm from the LZ, instead of 3 nm as stated in SOPs. (Tab JJ-3 thru JJ-4) As the MA slowed, the MP started a descent to 100 feet AGL. (Tab JJ-3 thru JJ-4) The MCR relayed the "one minute" call to the MA passengers. (Tab V-19.4, V-66.3) The MA slowed rapidly as the nacelles were rotated towards the helicopter position. (Tab V-6.7, V-10.19, Tab JJ-3 thru JJ-4) At 0.79 nm from the LZ, the MA was at approximately 147 KCAS (180 KGS) and 150 feet AGL. (Tab JJ-3 thru JJ-4) The normal speed at the 1 nm point should have been approximately 110 KGS. (Tab V-1.10, V-7.17, V-67.5) At 0.5 nm to the LZ, the MA had slowed to approximately 115 KCAS (128 KGS). (Tab JJ-3 thru JJ-4) The normal speed at the 0.5 nm point should have been 60 to 70 KGS. (Tab BB-31) The MP's rapid deceleration slowed them down from 147 KCAS (180 KGS) to 102 KCAS (125 KGS), between 2008:58Z and 2009:08Z. (Tab JJ-3 thru JJ-4) Due to the right quartering tailwind, the MP maintained an approximate eight degree right crab as he corrected his ground track en route to the LZ. (Tab J-10 thru J-22, Tab Z-27, Tab JJ-3 thru JJ-4)

From 2008:58Z to 2009:08Z, the MA's total fuel value decreased by 74 pounds, which equates to a rate of 26,640 pounds per hour. (Tab JJ-41 thru JJ-49) The engines are capable of commanding a maximum burn rate of 6,000 pounds per hour. (Tab JJ-49) The A-10 video of the last 20 seconds of the mishap flight showed a substance trailing the MA starting at approximately 2008:57Z. (Tab Z-27, Tab HH-25 thru HH-31) Two separate trails remained behind the MA for several seconds. This occurred several times up until approximately 2009:12Z, which was three seconds before ground impact. A very excited discussion occurred in the cockpit seconds prior to impact. (Tab V-60.28 thru V-60.29, V-60.36, V-72.1) A member of the MCR counted down "10, 9, 8, 7" rapidly and at "7" the aircraft impacted the ground. (Tab V-20.4) MTS heard several aircraft generated voice warnings upon impact. (Tab V-60.22)

f. Impact

The MA impacted the ground at approximately 2009:15Z on 8 April 2010 at N 32° 4.7479' E 066° 47.1487' at 5,226 feet MSL. (Tab M-7, Tab Z-27) This was 0.23 nm short of the intended LZ. The MA had all three landing gear down and locked, the nacelles nearly vertical, and the speed was approximately 75 KGS. (Tab Z-27, Tab JJ-3 thru JJ-4)

(Landing gear touchdown tracks)

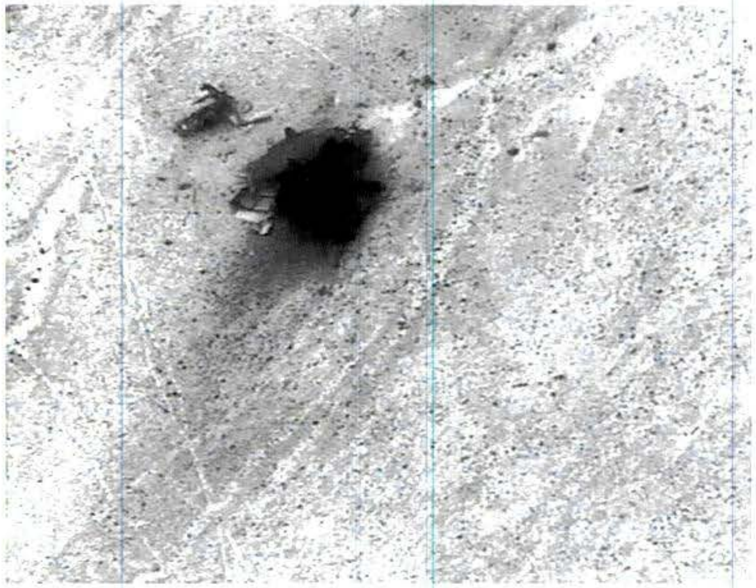
The right main landing gear (MLG) touched down four feet prior to the left MLG. (Tab V-48.3, Tab Z-25) The MA's pitch attitude was less than 14 degrees pitch up at touchdown. (Tab Z-3) The MLG rolled for nine feet prior to the ramp contacting the ground. While the ramp scraped the ground, the MLG continued to roll for another ten feet. The nose gear then impacted the ground and rolled for three feet. The MLG stayed in contact with the ground throughout this time. The MLG made impressions in the sand that were approximately eight inches deep, with the right side MLG slightly deeper than the left MLG. (Tab Z-3, Tab GG-4) The impressions made by the nose landing gear were approximately 12 inches deep and nearly centered between the MLG marks. After the initial impact, the nose wheel became airborne again for five feet and then hit the ground and fully collapsed. The nose of the aircraft (Forward Looking Infrared (FLIR), probe, nose cone) then began to plow into the soft dirt. (Tab V-33.6) Two feet later, the left MLG lifted off the ground slightly while the right MLG continued to roll for 13 feet. (Tab Z-3) The nose of the aircraft plowed deeper into the soft dirt while the right MLG was still in contact with the ground.

After rolling on its landing gear for a total of approximately 45 feet, the MA's nose then impacted a small, two-foot deep, natural drainage ditch which created a pivot point for the MA to flip tail over nose. (Tab V-48.4) The tail went over the nose in a slightly left wing low attitude. The nose remained in contact with the ground, while the rest of the MA began separating just behind the cockpit. (Tab V-7.35, V-33.11) The MA continued to flip and the proprotor blades began to hit the ground 30 feet later. The left proprotor blades hit three feet prior to the first strike of the right proprotor blades. There were 14 strikes on each side before the proprotor hubs struck the ground, 277 feet after the initial impact. The initial four strikes averaged approximately 8 feet apart. (Tab HH-25 thru HH-31) Proprotor "broomstraw" effects[3] appear on the ground after about 10 rotor strikes. (Tab V-7.34, V-39.5, Tab Z-9, Tab EE-38) The MCP, still strapped to the right seat, fell from the cockpit through an opening created during the rollover, after his seat attachment points broke loose. (Tab V-1.21, V-7.34 thru V-7.35, V-19.6, V-39.5, V-48.7, V-67.7)

Initial explosions occurred at 2009:18Z. (Tab Z-27) At 2009:20Z, dirt from the impact kicked up, followed by a second larger explosion. (Tab Z-27) The vertical tail section impacted the ground as the MA landed on its back, causing the tail section to break off. (Tab V-7.25, V-21.6, V-33.6) The MA slid an additional 50 feet, leaving the tail section detached near the left side of the fuselage. (Tab Z-23) The MA came to rest at 2009:22Z, with the cockpit collapsed and nearly severed. It was folded back, on the ground, under the roof of the airplane as it came to rest on its back. During the crash sequence the right wing broke off at the wing root. The left wing broke off near the nacelle and caught on fire. (Tab V-7.25) The rear of the MA was completely open at the edge of the ramp. (Tab V-7.25, V-7.35, Tab Z-3) The MA came to rest facing approximately 170 degrees from the initial direction of impact. (Tab V-7.26 thru V-7.27, Tab Z-23)

---

[3] The proprotors are designed to disintegrate or broomstraw upon contact with the ground which prevents them from causing other damage.



(Post-crash wreckage before kinetic destruction)

g. Life Support Equipment, Egress and Survival

The CV-22 is not equipped with ejection seats. (Tab EE-61) The MP, MCP, and MFE were secured in their cockpit seats. The MTS was secured by his gunner's belt around his waist hooked to a tie-down ring on the cabin floor near the ramp hinge. (Tab V-60.6) The final position of the MA was upside down with the nose and tail sections opened due to damage sustained in the crash sequence. (Tab V-3.6, V-48.4) The fuselage was otherwise intact. (Tab V-7.34, V-49.9) The surviving passengers and MTS were able to egress the MA, either with or without help from the occupants who were the most mobile. (Tab V-3.8, V-4.12, V-60.6 thru V-60.7) Several team members moved pieces of wreckage and cut away equipment and safety lines, to remove all occupants from the fuselage through either the open tail section or the open nose section. (Tab V-4.12, V-21.6 thru V-21.7) Chalk 2 and Chalk 3 passengers and Combat Search and Rescue (CSAR) forces removed the MP and MFE from the cockpit section of the wreckage. (Tab V-33.3 thru V-33.4, V-49.5 thru V-49.6, V-49.9) None of the emergency egress exits were activated or used in the mishap. (Tab V-3.17, V-41.8)

All four mishap aircrew members sustained forces to the head in excess of the specification requirements for the HGU-56/P helmet. (Tab HH-11 thru HH-12) The MFE's body armor sustained 2 one-quarter inch holes in the trauma plates, which stopped an object from piercing his chest. (Tab HH-12)

MCP's seat had fallen out of the cockpit during the crash sequence and was located 30 meters away from where the aircraft came to rest. (Tab V-49.5, V-63.11) When MCP awoke, he was still strapped into his seat. (Tab V-1.21) CHK1A unbuckled the MCP. (Tab V-19.6) The MCP's survival radio had a broken battery compartment, preventing him from using it to call for rescue forces. (Tab V-1.21 thru V-1.22, V-49.5) The MP's night vision goggles (NVGs) broke in the crash sequence, separating the two tubes. The HUD was still attached to the right tube. (Tab K-23, Tab V-39.10, Tab Z-21)

(MP's right NVG tube with HUD attached)

Seats are not mandatory when conducting missions with special operations forces, IAW USSOCOM, US Air Force and Navy instructions, therefore the MA had all cabin passenger seats removed. (Tab BB-51 thru BB-59, Tab II-7) The team members secured themselves to the MA using the standard safety harness attached to their combat uniform belts. (Tab V-3.4, V-4.13, V-4.18, V-4.20, V-5.5) They attached the snap link on the end of this device to either a metal tie-down ring on the floor of the MA, or to the rope attached to the tie down rings on each side of the cabin floor near the bulkheads. (Tab V-3.4, V-4.13, V-4.18, V-4.20, V-5.5) The rope was a new piece of equipment for the 8 SOS, purchased just prior to this deployment. (Tab II-7) The safety lines for some team members broke, while others remained intact, leaving some people dangling from their attachment point since the MA came to rest upside down. (Tab V-19.6, V-20.5, V-21.6) Several sustained abdominal injuries. (Tab X-3 thru X-4) These safety harnesses are designed to keep team members in the aircraft, not necessarily protect them in a crash sequence. (Tab V-4.17, Tab BB-58)

(Safety line used by team members)

The board did not note any deficiencies in the egress system or life support equipment.

h. Search and Rescue

The crash was immediately noticed by the air assets involved in the mission. (Tab V-16.6, V-18.5, V-31.3) The crash position indicator, the emergency locator transmitter (ELT), activated as the MA impacted the drainage ditch at 2009:16.5Z, indicating a deceleration of greater than 12 G's. (Tab V-16.7, V-18.5, Tab II-57) Aircrew members on Chalk 2 and Chalk 3 heard the sound generated over the guard frequency at the time they observed the fireball of the crash, which they first thought was ordnance exploding on the LZ. (Tab V-10.6, V-11.6, V-12.3, V-22.4, Tab II-57) Chalk 2 attempted to make radio contact with the MCR and had no response. (Tab 16.7) Chalk 2 and 3 immediately aborted their approaches to the LZ. (Tab V-10.6) Chalk 2 flew over the crash site and observed that indeed the MA had crashed. (Tab V-10.6) Chalk 3 went back to the IP and orbited. (Tab V-15.10)

Helicopter gunships in the area quickly reacted to the accident by calling for medical evacuation (MEDEVAC) assets. (Tab V-68.2) Additionally the JOC was informed of the situation and assisted with coordination of the MEDEVAC assets. (Tab V-34.7, Tab II-16)

Meanwhile, the survivors of the crash began to emerge from the wreckage at 2011Z and began to extract, triage, and treat each other. (Tab V-3.7, V-34.4, V-45.8, V-53.2 thru V-53.3, V-68.1) Chalk 2 decided to land its team members to assist. (Tab V-10.6) They landed 1.5 kilometers south of the crash site at 2017Z. (Tab V-68.1) Chalk 2 team members, in contact with mission assets and Chalk 1 survivors at the crash site, ran to the site to assist, arriving at approximately 2034Z. (Tab V-10.21, V-49.4, V-68.2) During their movement to the site, the gunship provided assistance via radio contact with CHK2JTAC to cross two 12 foot deep wadis (natural drainage ditches). (Tab V-49.3) Chalk 3 orbited at the IP until the situation became clearer. (Tab V-15.11) They landed 800 meters east of the crash site at 2048Z. (Tab V-68.2) Their team members moved rapidly to the crash site to assist the crash survivors. Chalks 2 and 3 departed at approximately 2050Z due to low fuel. (Tab V-15.11, V-68.2) They intended to return to the crash site in order to assist with MEDEVAC operations. (Tab V-10.8, V-13.12, V-16.24, V-17.10)

(Wadis ½ mile east of LZ, looking west)

(Wadis ½ mile east of LZ, looking north)

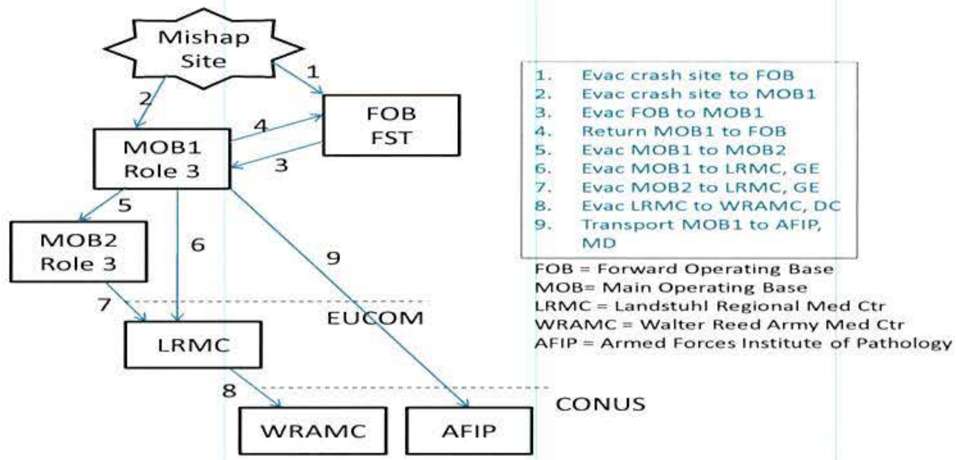
(Wadis and crash site during AIB aerial viewing from an Mi-17, looking northwest)


(Wadi and crash site, looking west, the landing direction)

Medical capabilities on the assault force included a medic, the company senior medic, CHK2C and the battalion surgeon, CHK3A. (Tab V-51.5) CHK1C had additional trauma training. (Tab V-21.10) He and other Chalk 1 passengers performed self aid and buddy care until other forces arrived. (Tab V-3.8, V-21.7, V-40.8, V-40.10, V-41.7, V-42.8, V-64.7, V-65.5, V-66.3 thru V-66.4) When the medics (Chalk 2) and battalion surgeon (Chalk 3) arrived, they continued to perform triage and prioritized casualty flow. (Tab V-51.2, V-53.2 thru V-53.3, V-63.4) CHK3A specifically re-triaged the MTS to the highest triage category which ensured that MTS would be on the first helicopter. (Tab V-63.3 thru V-63.5)

Four MEDEVAC helicopters arrived starting at 2059:28Z. (Tab V-68.2) All the wounded were evacuated to either the FOB or MOB1. The CHK2JTAC coordinated the numerous assets that were involved in the CSAR efforts. (Tab V-54.3) The JOC monitored the situation. (Tab V-14.3, V-22.25, V-28.13) The CV-22s remained at the FOB refueling area for approximately three hours. (Tab V-13.12, V-44.3) The JOC and MC directed Chalk 2 and Chalk 3 to standby. (Tab V-13.11, V-44.3) The MC elected not to use the CV-22s for MEDEVAC based upon the capabilities present and the relatively short distance to the crash site. (Tab V-28.13) At 2148:51Z, the last MEDEVAC helicopter departed the crash site. (Tab V-68.2)

The below diagram represents the overall evacuation routings used for all of the mishap crew and passengers. (Tab X-3 thru X-4)



Individual mishap crew members and passengers were evacuated via the following routings (routing numbers correspond to the diagram above), with final dispositions noted:

Individual	WIA/KIA	ROUTING
MP	KIA	1, 3, 9 for Autopsy
MCP	WIA	2, 5, 7, 8 – CONUS
MFE	KIA	1, 3, 9 for Autopsy
MTS	WIA	1, 3, 5, 7, 8 – CONUS
CHK1A	WIA	1, 3, 4 – Returned to Duty (RTD)
CHK1B	WIA	2, 4 – RTD
CHK1C	WIA	1 – RTD
CHK1D	WIA	1 – RTD
CHK1E	WIA	2, 4 – Then returned to CONUS by unit
CHK1F	WIA	2, 6, 8 – CONUS
CHK1G	WIA	2, 5, 7, 8 – CONUS
CHK1H	WIA	1 – RTD
CHK1I	WIA	2, 4 – RTD
CHK1J	KIA	1, 3, 9 for Autopsy
CHK1K	WIA	2, 5, 7, 8 – CONUS
CHK1L	KIA	1, 3, 9 for Autopsy
CHK1M	WIA	2, 6, 8 – CONUS
CHK1N	WIA	1, 3, 6, 8 – CONUS
CHK1O	WIA	1, 3, 6, 8 – CONUS
CHK1P	WIA	2, 5, 7, 8 – CONUS

NOTES: FOB FST = Forward Surgical Team at FOB, Considered a "Role 2" facility. MOB1 and MOB2 are "Role 3" medical treatment facilities, indicating full surgical and intensive care unit (ICU) capabilities. WIA = Wounded in Action; KIA = Killed in Action.
Immediately after the mishap, TF CC alerted a CSAR team. (Tab V-38.3) MC sent P1 with the CSAR team as the subject matter expert on the CV-22. (Tab V-28.13) TF CC, P1, CSAR1

through CSAR4 and a large security element departed at 2025Z on two H-47s from MOB1. (Tab V-38.3) Their mission was to evaluate the mishap site and recover sensitive items. (Tab V-38.3, V-48.2) Upon arrival at the mishap site at 2139:08Z, the CSAR team took over security of the site. (Tab V-49.6) CHK1B conducted a brief turn over with TF CC. (Tab V-20.6) Then the last MEDEVAC took off with all the remaining Chalk 1 passengers. (Tab V-38.3) CSAR2 led a team of CSAR, Chalk 2 and Chalk 3 passengers to extract the MP and MFE from the wreckage. (Tab V-16.24, V-33.3, V-49.9) They lifted large pieces of the aircraft which were under the fuselage, cut away straps and wires and removed the two aircrew members. (Tab V-53.7) CSAR4 and P1 assessed the wreckage, mapped the crash site area, and began removing sensitive items and personal equipment from the aircraft. (Tab V-7.27, V-33.9, V-48.6) The H-47s extracted Chalk 2 and Chalk 3 passengers, returning them to the FOB. (Tab V-38.4) The H-47s then returned to extract the CSAR team, TF CC and P1. (Tab V-37.12, V-38.4 thru V-38.5, V-49.7, V-51.3) They returned to MOB1 approximately four hours after the crash at 2312:50Z. (Tab V-68.3)

The JOC, the 8 SOS and the deployed maintenance personnel did not have a published plan to react to a downed CV-22 in the AOR.[4] (Tab V-25.12, V-28.15, V-37.8, V-58.5) Therefore, the recovery effort following the mishap was conducted by memory with the guidance of the TF CC and the MC. (Tab V-37.8) Following recovery of the wounded and KIAs, the primary consideration was the recovery of the sensitive items and denying the enemy the possibility of exploiting the aircraft. (Tab V-38.5 thru V-38.6, V-39.4) With assets overhead the crash site, security was well established and the enemy threat was virtually non-existent. (Tab V-31.9, V-47.7) Maintenance personnel provided information to the JOC of items and serial numbers to remove. (Tab V-56.9, V-58.2) Other lists were made by MX2, OCFP, other CV-22 aircrews, and the field support team, but not consolidated. (Tab V-23.14, V-24.4, V-57.2 thru V-57.3, Tab II-22) At least one of these lists included the Flight Incident Recorder (FIR) and the Vibration Structural Life and Engine Diagnostics (VSLED) system. At the crash site, P1 communicated via radio with the JOC to receive additional information on what to recover. (Tab V-29.27) During this time maintenance was standing by to assist with information for the recovery as well as with a Maintenance Recovery Team (MRT). (Tab V-55.4, V-56.4) P1 and the CSAR team removed all sensitive items from the aircraft to include the Data Transfer Module (DTM). (Tab V-7.27, V-37.13) The recording devices that the CV-22 has installed, such as the VSLED system and the FIR, were not recovered. (Tab V-7.27, V-28.20, V-37.9) The MC and P1 made the determination that the FIR was not installed on the aircraft, and that the VSLED was not reachable with the aircraft upside down. (Tab V-3.5, V-7.27, V-28.20, V-48.6) Although recovering the VSLED and FIR would have been difficult, the CSAR team was willing, equipped and prepared to recover anything on the aircraft if asked. (Tab V-48.6)

While at the crash site, P1 determined that the MA was not salvageable. (Tab V-28.33) Based on this information, the MC did not send the MRT. (Tab V-55.4) TF CC passed this information to higher headquarters over the radio and received direction to destroy the wreckage. (Tab

[4] The 8 SOS leadership had access to PMA-275 draft document on MV-22 crash recovery procedures. (Tab V-55.5, Tab II-19) This document contained lists of items to be recovered that included the FIR and VSLED. AFSOC A4 told the 8 SOS that this document did not apply in OEF due the time and equipment required to implement the procedures. (Tab II-19)

V-38.6) The wreckage was destroyed by precision guided bombs at approximately 0001Z. (Tab V-62.11, Tab II-16)

i. Recovery of Remains

The four deceased personnel (MP, MFE, CHK1J, CHK1L) were transported to the FOB during the MEDEVAC process. (Tab V-49.8) The MP and MFE were then transported on Chalk 3 to MOB1, where they were released to mortuary affairs, 54th Quartermaster Company. (Tab V-16.24, V-17.10, V-18.7) CHK1J and CHK1L were transported from the FOB to MOB1 via US Army H-60 helicopter, where they were released to mortuary affairs of the same unit. All four deceased personnel were subsequently transported to AFIP in Rockville, MD for autopsy. (Tab X-7, X-9) Personal effects and personal life support equipment went with the deceased to AFIP. (Tab HH-9 thru HH-10) Other aircrew life support equipment was released to the Safety Investigation Board (SIB) Medical Member and sent to Brooks City Base for analysis.

5. MAINTENANCE

a. Forms Documentation

(1) General Definitions

Air Force Technical Order (AFTO) 781 series forms and a computer database known as Integrated Maintenance Data System (IMDS), document Air Force aircraft maintenance and inspection histories. (Tab BB-45) In addition to scheduling and documenting routine maintenance actions, these tools allow aircrews to report aircraft discrepancies and maintenance personnel to document the actions taken to resolve the reported issues. Furthermore, the forms and IMDS provide a tool to research past aircraft problems to more effectively troubleshoot and solve new maintenance discrepancies.

Active forms consist of the AFTO 781 series forms currently in use by maintenance personnel to record aircraft condition and repairs.

Inactive forms are AFTO 781 series forms where all uncleared discrepancies are carried-forward to a new form, then retained for historical purposes.

Maintenance personnel use Time Compliance Technical Orders (TCTOs) to process system changes, usually aircraft part upgrades, which must be accomplished within a specific time period and by a specific date depending on the severity of the issue the TCTO addresses. (Tab BB-39 thru BB-41) A TCTO may also direct inspections or adjustments to equipment or parts already installed on the aircraft or those of ground support equipment. Time change items encompass routine maintenance actions which require components to be removed and replaced at a given number of flight hours or calendar days.

The red symbols established for use on maintenance documents make important notations instantly apparent. (Tab BB-46) They indicate the condition, fitness for flight or operation, servicing, inspection, and maintenance status of the aerospace vehicle or equipment.

- A Red X annotates that an aircraft is considered unsafe or in an unserviceable condition. (Tab BB-46) The unsatisfactory condition must be corrected and the symbol cleared before flying the aircraft.

- A Red Dash indicates an unknown condition of the equipment. A more serious condition may exist. (Tab BB-47) The aircraft is still flyable.

- The Red Diagonal indicates a discrepancy exists on equipment, but is not sufficiently urgent or dangerous to warrant the aircraft's grounding or discontinued use. (Tab BB-48)

A repeat discrepancy occurs when the same malfunction in a system/subsystem appears on the next flight or flight attempt after maintenance cleared the original discrepancy. (Tab BB-54)

A recurring discrepancy is when the same system/subsystem malfunction occurs on the 2nd through 4th flights/attempted flights after the original flight in which the malfunction occurred and was cleared by maintenance. (Tab BB-54)

(2) Active Forms

On the day of the mishap there were 16 open 781A discrepancies consisting of zero red X's, five dashes, and eleven diagonals as depicted below. (Tabs D-43 thru D-56)

Symbol	Job Control Number (JCN)	Discrepancy
--	100470102	RH Mast Nut Bolt Torque ck due
--	100470102002	LH Mast Nut Bolt Torque ck due
--	100479031	In-flight MATT Ops ck due
/	100484031	Radio #4 Test Antenna Installed
/	100530099	TCAS cabin video #2 does not output useable video
--	100570172	C/W TCTO 1V-22(B)-761
/	No JCN	L/R Engine anti-ice valve F(P)
/	100604622	Proprotor Fail left deice F(P)
/	100604623	Leak in cabin near upper windshield
/	No JCN	LH upper rudder bushing worn within limits
/	No JCN	Panel 6RO3 upper pin latch housing worn
/	100930057	Pilots Secondary lighting assembly x2 INOP
/	100930065	Panel 6LO7 Lower latch worn
/	100960078	RH engine compressor drain line broken
--	No JCN	SIRFC Ops ck due
/	No JCN	NLG static ground wire worn too short

All existing active aircraft AFTO 781 series forms were reviewed for accuracy and completeness. Several documentation errors were noted, but did not pose a safety of flight issue and had no bearing on the mishap.

There is no record of TCTO 1V-22(C)B-761, a one-time-inspection of the left and right swashplate actuator attach bolts, being accomplished at the time of the last 35 hour inspection. The TCTO was received by 1st Special Operations Maintenance Group (SOMXG) on

26 February 2010. (Tab BB-32 thru BB-35) Plans and Scheduling briefed the 801st Special Operations Aircraft Maintenance Squadron (SOAMXS) on 26 February 2010. Compliance was required no later than the next 35-flight hour inspection. Maintenance personnel performed the 35-hour inspection on 3 April 2010, but the TCTO required inspection was not performed. Maintenance incorrectly used the ground date of 1 May 2011 as the due date. (Tab D-45, Tab U-33, U-34, Tab BB-42) A red X should have been placed in the active forms, restricting the MA from flight until TCTO completion. (Tab BB-32 thru BB-36, BB-36 thru BB-44, BB-46)

The swashplate actuators are redundantly mounted, therefore the failure of a single attach bolt would not be noticeable to the flight crew and aircraft flight characteristics would remain constant for flight. (Tab II-8) If both mount points fail a loss of rotor disk control would occur. The likely effect would be asymmetrical thrust. During airplane mode, this may be displayed as an uncommanded yaw of the aircraft. During helicopter mode, an uncommanded roll is likely. No evidence exists the MA suffered the loss of a swashplate actuator bolt.

(3) Inactive Forms

A thorough review of the complete aircraft historical file, to include TCTO status, AFTO Form 95's, major inspection packages and archived data within the IMDS in the 12 months prior to the mishap was accomplished. Several documentation errors were noted, but none bearing to the mishap. (Tab U-34)

The 801 SOAMXS, in conjunction with AFSOC, determined the intake, inlet and exhaust inspections for foreign object damage (FOD), both before and after maintenance runs, as required by AFI 21-101 were not applicable to the CV-22 and did not perform or document these inspections. (Tab U-37, Tab D-115) A waiver to this requirement could not be located. (Tab U-38) The engines were unavailable to perform a FOD analysis. (Tab II-5)

The MA flew 9 sorties, totaling 13.0 flight hours from 30 March 2010 (when pulled off the ship) to the morning of the mishap flight. (Tab D-155 thru D-166, Tab AA-5, AA-9, AA-17, AA-18, AA-23, AA-25, AA-28, AA-33)

b. Inspections

Regularly scheduled maintenance performed at specific flying hour intervals are considered phase inspections. The CV-22 has a 210-hour phase inspection cycle. The MA completed a 630-hour Phase C on 4 October 2009 with the aircraft hours at 620.2. (Tab U-9 thru U-12) A Phase C inspection comprises 41 primary tasks. The MA had approximately 100 hours remaining before the next 840-hour Phase D inspection. (Tab D-3, D-8, D-58)

The last flight hour based scheduled maintenance actions were a 35-hour inspection performed 3 April 2010, and a 105-hour inspection and a compressor/turbine wash accomplished 4 April 2010. (Tab D-113 thru D-117) The 35-hour and 105-hour inspections comprise 51 main tasks.

On 8 April 2010, at 0530Z, maintenance personnel conducted the last minor scheduled inspection, a combined basic preflight/postflight inspection on the MA approximately 14 hours before the mishap. (Tab D-8) This type of inspection is valid for 72 hours and was still valid when the MA took off for the mishap mission. The maintenance documentation confirmed that, with the exception of TCTO 1V-22(C)B-761, all inspections were accomplished in accordance with applicable maintenance directives. (Tab D-45)

c. Maintenance Procedures

Environmental conditions have driven increased preventable-maintenance actions such as rinsing the aircraft, nacelles, engine air particle separator (EAPS), and engines and wiping down hydraulic actuators. (Tab V-25.3, V-35.10) Compressor and turbine washes are performed when the engine percent power (EPP) indicates low power, below 95%, and during 35-hour inspections. (Tab V-30.6) After the mishap, procedures were adjusted to perform these engine washes when engine EPP fell below 98% and after every 10 austere landings. (Tab V-30.8)

With the exception of Intake/Inlet/Exhaust inspections not being performed and/or documented in the forms, and the open TCTO, maintenance procedures on the MA were performed in accordance with applicable TOs and AFIs, with only documentation errors, at the time of the mishap. (Tab U-37, U-38, U-39, Tab BB-32 thru BB-35, BB-49 thru BB-52, BB-55)

d. Maintenance Personnel and Supervision

Maintenance personnel statements indicated all preflight activities were normal and all personnel involved in the preflight and launch of the MA were experienced and qualified. (Tab GG-9 thru GG-18) A thorough review of individual military training records and special certification roster for all personnel who performed maintenance on the MA indicated proper training on all tasks they accomplished. (Tab U-8)

While deployed, maintenance and operations are in a combined unit, where instead of being separately managed under their respective group commander, maintenance worked directly for the MC. (Tab V-25.2 thru V-25.3) Maintenance supervision indicated they had a good working relationship with operations supervision. (Tab V-58.3, V-25.2 thru V-25.3) The maintenance supervision were engaged in daily maintenance activities and actively involved in the repair and launch of aircraft. (Tab V-25.2 thru V-25.3, V-35.2, V-58.3) In addition to the items addressed in paragraph 5a(2), several areas of concern were noted, but there is no evidence they were causal to the mishap.

- The unit had not received all of their equipment at the time the 35-hour inspection was performed, as several items were still in transit. The MX OIC stated that the hardcopy TCTO-761 was not available at the time of the mishap. The unit was in its deployed location for almost two weeks before a copy of the TCTO was available electronically. (Tab U-34)

- The unit did not have a documented deployed location response plan for crashed, damaged, disabled, aircraft recovery (CDDAR) as required by AFI 21-101, paragraph 14.10.1. (Tab V-28.38, V-58.8, V-25.12, Tab DD-6) Although maintenance has some MRT capability, this does not fulfill the CDDAR requirement. (Tab V-55.4, V-56.3 thru V-56.4) The MX OIC was not familiar with CDDAR or whether such a program existed at home station. (Tab V-58.8) The MC was only familiar with a downed aircraft checklist that applied at home station in a peacetime setting. (Tab V-55.2)

- P3 stated that "the average CV-22 pilot probably did not know before this incident that there was a FIR of any kind because the Dash-1 guidance is at best misleading, certainly inaccurate." (Tab V-46.11) The MC didn't think a FIR was on the aircraft, but thought it was going to be on a future modification. (Tab V-28.20, V-46.11 thru V-46.12, V-46.14) At the time of the mishap, only 13 maintenance personnel knew the MA contained a flight incident recorder. (Tab V-28.20, V-46.11, V-43.14, V-56.5)

e. Fuel, Hydraulic, and Oil Inspection Analysis

Supreme Fuels Laboratory tested samples of fuel taken post-accident from the truck that refueled the MA on 8 April 2010. (Tab J-3 thru J-5) All fuel samples tested within limits and free from contamination.

Hydraulic fluid samples taken post-accident from the hydraulic servicing cart that serviced the MA prior to the mishap were sent to the Air Force Petroleum (AFPET) Office Laboratory at Wright-Patterson AFB, Ohio. (Tab J-6 thru J-7) The samples also tested within limits and free from contamination.

Oil samples taken post-accident from the oil servicing cart used to service the MA prior to the mishap tested within limits and free from contamination. (Tab J-8 thru J-9)

No fluid samples were obtained post-accident from the MA. No evidence was found that servicing equipment or fuels, hydraulics, or oil contributed to the mishap.

f. Unscheduled Maintenance

A review of IMDS and AFTO 781 maintenance records (12 months prior to the mishap) highlighted the following noteworthy items:

- Three repeat discrepancies (Tab U-4, U-14, U-16)
  - Hydraulic system 2 monitor fail, corrected 13 August 2009
  - Aircraft rotor system out of balance, corrected 1 September 2009
  - Right hand proprotor gearbox debris sensor post F(P), corrected 6 April 2010

- Four recur discrepancies (Tab U-4, U-13, U-15)
  - No FLIR video, corrected 7 August 2009
  - Infrared jammer failure (two entries), corrected 15 October 2009
  - Radio #3 intermittent, corrected 20 February 2010

The combined repeat/recur rate was 3.2%. (Tab U-16) A maximum rate has not been established by the 1 SOMXG.

On 7 May 2009, the MA's right hand nacelle blower failed during flight. A one-time flight was authorized for return to home station. Seven technical assistance requests were submitted for repair guidance. Replacement of both the left hand (for evidence of rubbing) and right hand blowers and damaged components corrected the problem on 11 May 2009. (Tab U-4, U-17)

The Aircraft Maintenance Event Ground Station (AMEGS) recorded a landing with 8.5 fps (feet per second) vertical velocity on 9 February 2010. Maintenance tech data only requires an inspection when vertical velocity exceeds 12.5 fps. (Tab II-10)

On 8 April 2010, the left hand Engine Air Particle Separator (EAPS) failed for a total of four minutes, 26 seconds during austere conditions, leaving the left engine unprotected during dusty conditions during that period. Automated engine performance checkpoints did not detect any abnormal engine degradation during that flight.[5] (Tab II-3)

A review of the MA's performance for the one year period prior to the mishap revealed that 87 of 213 sorties flown landed either Code I or Code II.[6] (Tab U-20 thru U-32)

A review of the V-22 Tech Assist Management Program (VTAMP) database indicated a total of 93 technical assistance requests were made since the receipt of aircraft 0031. (Tab U-18 thru U-19)

Maintenance completed all corrective actions for unscheduled maintenance in accordance with applicable technical data and engineering guidance. There is no indication of unscheduled maintenance being a factor in the mishap.

6. AIRCRAFT AND AIRFRAME

a. Condition of Systems

As preparation for shipment by sea, the MA rotor blades, and exterior openings and window were sealed for protection from the elements. The engine and auxiliary power unit systems were preserved using established procedures. (Tab D-90 thru D-154, V-25.2, V-43.7 thru V-43.8)

The aircraft handled the ship transport to the AOR well. (Tab V-43.7) Maintenance personnel described having very few issues while prepping the aircraft for return to flight. (Tab V-23.8, V-25.2) Port Maintenance support was the best maintenance had seen in years. (Tab D-90 thru D-154, V-43.7, Tab GG-37 thru GG-40) Transport by ship resulted in not having to perform a 35-hour inspection for all aircraft upon arrival in the AOR. The MC and Pro Sup praised this method of deployment. (Tab V-23.8, V-25.2, V-28.23 thru V-28.24)

---

[5] During an operational test in 2006, a CV-22 experienced engine degradation to below 95% EPP while hovering in a dusty environment, due to the engines ingesting dust. As a result, an unanticipated power loss occurred. A deficiency report was submitted. (Tab BB-36)

[6] Code I is no discrepancies noted. Code II is minor discrepancies noted, not restricting the aircraft from flight.

At the time of the mishap, the MA's total aircraft time was 740.3 hours. The #1 engine (left engine), serial number (S/N) ECA130322, had 122.9 total engine and on wing hours since the install date of 2 October 2009, with no overhauls. (Tab D-3) The #2 engine (right engine), S/N CAE130287, had 224.5 total engine hours and 70.5 on wing hours since the install date of 1 December 2009 and an overhaul date of 19 August 2009.

A thorough review of the MA VSLED data by Rolls-Royce indicated gradual power degradation of both engines consistent with operation in austere conditions. (Tab U-7) Airplane mode power assurance checks (PAC) on 6 April 2010 showed 99.5% available for the left engine and 95.3% available for the right engine. (Tab U-5, U-6) The MA flew 1.5 hours after the last PAC. (Tab D-57, AA-9) Engines are replaced if the PAC remains below 95% after maintenance actions. (Tab V-10.24, V-12.9, V-26.5)

- Engine trend data was unavailable from 23 February 2010 to 5 April 2010, consisting of eight flights (11.2 flight hours). (Tab HH-24) The absence of this information did not negatively affect the trending capability of the system.

- Since installation, neither engine had experienced a compressor stall, and only one flameout was detected. Routine ground checks include an engine shutdown that would be recorded as a flameout. (Tab II-24)

- The accessory gearbox, compressor and turbine were all within established vibration limits.

Prior to the mishap sequence, the aircraft, engines, and systems appeared to operate within normal mission parameters. (Tab V-1.11, V-60.7) Due to the MA being destroyed for security purposes, impact analysis was not conducted at the crash site. Several pieces of the wreckage have been removed to FOB Apache.[7] (Tab II-3)

(Wreckage at FOB Apache)

[7] The razor wire was not part of the wreckage. Personnel at FOB Apache placed the razor wire and other pieces of trash with the aircraft wreckage.

b. Testing and Analysis

Parts of the MA's left nacelle and engine, and some of the right nacelle have been recovered. The left engine was shipped back to the United States and inspected by Rolls-Royce. (Tab II-5, II-51 thru II-56) After teardown and inspection, engineers determined that the left engine was operating at the time the engine impacted the ground. The left engine anti-ice and coanda valves were found in their normal power-off positions. Power settings and engine health could not be positively determined. (Tab II-51 thru II-56)

Engineers analyzed video of the MA just prior to impact and the ground marks made by the proprotor blades as they struck the ground when the MA flipped over shortly after the ground roll. (Tab HH-25 thru HH-31) They determined that the proprotor speed, (Nr) at touchdown was approximately 308 to 317 RPM. This RPM equates to 78% to 80%, with a margin of error of 20% and 10% respectively. Normal Nr at that airspeed and nacelle setting would have been 104%. Only a dual engine failure condition can result in a reduction in Nr. (Tab II-59) An engine flameout is reported by the Full Authority Digital Engine Control (FADEC) when gas generator speed (Ng) decreases rapidly or drops below 54%. A continuous and automatic engine relight capability will activate when the flameout is detected. The flameout condition is also reported to the crew as a warning as long as the condition still exists.

Neither the installed FIR, nor VSLED have been recovered. (Tab U-3, U-6, Tab V-28.20, V-37.9) An analysis could not be performed on these systems.

7. WEATHER

a. Forecast Weather

The weather forecast the mishap crew obtained comprised of a single sheet. (Tab F-3) The 8 SOS policy was to obtain this weather sheet via email from MOB2, and check observations of regional stations if available. (Tab V-62.3) However, they did not check automated observation at the FOB that night. (Tab V-28.27 thru V-28.28) Additional data could have also been obtained by calling the weather forecaster at MOB2. (Tab V-28.30) On the date of the mishap, there was not a weather forecaster supporting the mission at MOB1. (Tab V-28.31, V-37.14 thru V-37.15) Winds were forecasted at MOB1 to be light and variable. (Tab F-3) Sky condition was forecasted to be scattered at 120 and 200 (12,000 and 20,000 feet respectively above the surface). The weather flimsy also called for winds in the Zabul Province (the region of the LZ) to be westerly at 25 knots – this is in the section labeled "Orbit Weather" and is valid for Flight Level 180 (18,000 MSL). (Tab F-3) Moonrise was listed as occurring at 2215Z on 8 April 2010, and moonset was at 0931Z on 9 April 2010, meaning there was to be no moon illumination during infiltration. (Tab F-3) Visibility was forecasted as unlimited. The weather brief the crew received that night did not include any additional data outside the briefed "flimsy" sheet. (Tab V-28.27 thru V-28.28) With the exception of illumination, weather was described as "not a factor or concern" for the mission that night by numerous aircrew members. (Tab V-10.4, V-15.4, V-67.3)

Additional weather observations available, but not used, included an automated weather reporting station located approximately five miles from the LZ. (Tab F-4) This station, however, was malfunctioning at that time and produced an erroneous report that showed the same data over a 12 hour period. (Tab V-15.22, V-62.13) An additional unused weather source was FOB Wolverine, located approximately 14 miles southeast of the LZ and five miles southeast of the initial point (IP). Its weather observation is augmented by a human observer, and reported winds and temperature as 130 degrees at six knots (130/6) and 18 degrees (Celsius) at 1855Z; 120/7 and 20 degrees at 1955Z and 140/6 and 20 degrees at 2005Z; and 150/3 and 20 degrees at 2055Z. (Tab F-5, Tab W-19) FOB Wolverine lies in a valley away from the plateau where the MCR's LZ and the FOB lies. The weather at FOB Wolverine, MOB1 and the FOB where the mishap crew conducted its AMB prior to the mishap sortie, are all typically very different from one another. (Tab II-14)

Additional forecasted weather was available for FOB Wolverine and the FOB for the mishap night, but not used. (Tab W-4, W-5) This weather forecast is available from the USAF weather personnel who routinely support the large number of US helicopters that operate in southern Afghanistan. (Tab V-29.22) The 8 SOS personnel did not consider this source during their advanced echelon (ADVON), the spin-up period, or the night of the mishap. (Tab V-55.1, V-29.22 thru V-29.23) The weather forecast for the FOB, issued at 1329Z and valid from 0730Z on 8 April 2010 to 0730Z 9 April 2010, called for winds during the mishap period to change from variable at 6 knots (at 1600Z) to 050/10 gusting to 15 knots (starting at 1700Z until 0600Z the next day). The next forecast for the FOB, issued at 1530Z, called for winds to become 060/10 gusting to 15 knots starting at 1900Z, until 0500Z the next day. Sky condition was forecasted to be few clouds at 200 with unlimited visibility for both the FOB and FOB Wolverine forecasts. (Tab W-4, W-5) During the same time periods, the forecasted winds at FOB Wolverine called for variable at 6 knots (1500Z to 0600Z the next day), unlimited visibility, and sky condition of few clouds at 200. (Tab W-13, W-14)

b. Observed Weather

The weather at takeoff from MOB1 was essentially calm. (Tab F-6) At the FOB, the winds were light or calm when the mishap crew arrived. (Tab V-1.17, V-3.17, V-6.3, V-10.26, V-11.5, V-15.16, V-16.3, V-19.2, V-20.2, V-64.5, Tab II-14) When the mishap flight took off from the FOB, the pilots did not note any changes to the winds. (Tab V-1.17, V-10.4, V-11.12, V-15.16, V-16.3) However, the tower NCOIC, who noted the windsock, reported the winds as having changed to the typical direction for that time of night (northeasterly) at 17 knots when the CV-22's took off at 1956Z, approximately 1.5 hours after arrival at the FOB. (Tab II-14) He noted this because the MCR departed with a tailwind and had not asked him about winds either in person or on the radio. None of the mishap flight pilots reported knowing about or consulting the tower for weather information during the ground time at the FOB. (Tab V-10.4, V-15.3 thru V-15.4)

During the mishap flight no adverse or unforecast winds were observed by any crewmembers until just before the mishap occurred. (Tab V-1.7, V-10.26, V-13.10, V-11.5, V-15.11, V-15.16, V-16.14, V-17.6) CHK3FE noticed a 17 knot tailwind and reported it to his aircraft commander just prior to then MA's impact. (Tab V-17.6) The winds at the mishap site were northeasterly at approximately 20 knots, which was a right quartering tail wind for the MA landing to the west. (Tab V-10.18, V-10.26, V-11.5, V-11.6, V-13.25, V-15.7 thru V-15.8, V-16.4, V-17.6, Tab Z-27, Tab GG-3) Temperatures were not noted to be different than the forecast of 20 degrees. (Tab

V-13.4, V-15.17 thru V-15.18, Tab W-13) Illumination was described as being very dark with haze. (Tab V-10.5, V-11.4, V-15.6) One pilot described the conditions as being consistent with a "varsity night." (Tab V-67.23) No other unusual or unexpected weather phenomena were reported by any crewmembers.

The post-accident weather continued to be windy (winds out of the northeast in the teens to lower twenties) along the plateau that included the mishap site and the FOB throughout the night. (Tab V-15.21) At FOB Wolverine, the winds remained southeasterly at less than five knots until the next morning. (Tab W-10)

c. Space Environment

Not applicable.

d. Conclusion

The MA was operating within its operational weather limitations except for the tailwind landing. Training weather limitations for night visual flight rules (VFR) in the CV-22 are 1,500 feet ceiling and three miles visibility in airplane mode, and 500 feet ceiling and two miles visibility in conversion/helicopter mode. Operational weather limits are listed in AFI 11-202 Vol 3, General Flight Rules, under the helicopter category. Illumination limitations rest with the pilot in command, unless it is less than 0.8 millilux, which requires additional approval from the MC. The MC approved the low illumination for this mission. (Tab V-28.26) Wind limitations are listed in the Dash-1 flight manual as 10 knots maximum tail wind. (Tab V-7.18, V-8.10, V-29.24) Different aircrew members reported a wide variance of tailwind limits for landing the CV-22. (Tab V-7.18, V-8.10, V-15.9, V-17.6, V-22.14, V-23.10, V-24.9, V-28.11, V-46.19) The landing direction placed the MA outside of the flight manual tailwind limit.

8. CREW QUALIFICATIONS

a. Mishap Pilot

The MP was a highly experienced instructor pilot. He had 18 years of flying, a command pilot aeronautical rating and a total of 3,655 flight hours. (Tab G-5, G-10) His initial flight training occurred in 1992 at Ft Rucker in the US Army. After transferring to the US Air Force in 1999, he completed training in the MH-53 at Kirtland AFB NM from November 1999 to September 2000. (Tab G-78) He completed initial instructor upgrade in the MH-53 in 2003, and later that year qualified as an instructor in the UH-1H. (Tab G-77) He completed initial training in the CV-22 in April 2007 and upgraded to instructor pilot in February 2008. (Tab G-75, G-76, G-82) He was nearly complete in his upgrade to evaluator pilot in the 8 SOS at the time of the mishap. (Tab V-7.10, V-18.10) Fellow aircrew members described him as one of the most experienced and highly qualified CV-22 pilots in the Air Force. (Tab V-7.9 thru V-7.10, V-28.10) He was one of only three squadron flight lead aircraft commanders deployed to the AOR. (Tab V-28.29) Flight lead is a separate certification in the 8 SOS. (Tab G-73)

The MP participated for the entire two weeks of the Ft Bliss training exercise in February 2010 flying a total of 22.2 hours. (Tab G-16, Tab V-7.13) He completed the training for the new avionics software suite prior to deploying. (Tab V-7.23) He conducted three simulator periods during the predeployment preparation, practicing mission representative scenarios with his hard crew. (Tab V-69.1, V-70.1, V-71.1) Between 5 and 24 March 2010, he also flew 17.3 hours in the simulator predeployment training, most of that time as an instructor pilot. (Tab G-16) During the unit spin-up period of 5-6 April 2010 after arriving in country, the MP flew two familiarization sorties. (Tab AA-17, AA-23) On 7 April 2010, he flew a DV support sortie. (Tab V-67.22, Tab AA-12) During the period of 1 January 2010 until the mishap, the MP logged 13 NVG sorties in the aircraft, three NVG sorties in the simulator, nine LVAs in the aircraft and four LVAs in the simulator. He flew the most recent LVA on 6 April 2010. (Tab CC-3) Following the unit spin-up period, the MP, as the crew commander of his deployed hard crew, declared to the MC on 6 April 2010 that he and his crew were ready for combat missions. (Tab V-28.29)

According to the unit's go/no-go list on 8 April 2010, the MP had one overdue ground training event (combat mission training refresher). (Tab G-72) The MC verified that this was incorrect information in the database and the MP was current. (Tab V-28.36) The MP had not signed off the four latest flight crew information file (FCIF) items on the unit's FCIF tracking sheet on 8 April 2010. (Tab K-19) The MC had no explanation for this, but did state that he was certain the MP was aware of the information contained in those four items. (Tab V-28.39)

Recent flight time is as follows: (Tab G-19, G-21, G-23)

	Hours	Sorties	Sim hours	Sim sorties
30 days	10.5	8	12.8	5
60 days	22.4	18	12.8	5
90 days	42	30	22.8	9

b. Mishap Copilot

The MCP was an experienced pilot, but new to the CV-22. He had nine years of flying, a senior pilot aeronautical rating, and a total of 2,621 flight hours. (Tab G-25, G-30) Following completion of pilot training in April 2002, he completed initial qualification in the UH-1N in July 2002. (Tab G-30, G-160) In September 2004, the MCP upgraded to instructor in the UH-1N. (Tab G-151) He also upgraded to instructor pilot in the UH-1H in February 2006. (Tab G-121) He completed initial training in the CV-22 in September 2009. (Tab G-120) His squadron Director of Operations (DO) described the MCP as a solid pilot with a promising future in the unit. (Tab V-2.15)

The MCP participated in both train up exercises in January and February 2010, flying a total of 28.3 and 15.9 hours, respectively. (Tab G-37 thru G-38, Tab V-1.15) He completed the training for the new avionics software suite prior to deploying. (Tab V-7.23) He conducted three simulator predeployment training sorties, practicing mission representative scenarios with his hard crew, for a total of 6.0 hours. (Tab G-33, G-34, Tab V-69.1, V-70.1, V-71.1) During the unit spin-up period of 5-6 April 2010 after arriving in country, the MCP flew two sorties. (Tab AA-17, AA-23) On 7 April 2010, he flew a DV support sortie. (Tab V-67.22, Tab AA-12) During the period of 1 January 2010 until the mishap, the MCP logged eight NVG sorties in the aircraft, three NVG sorties in the simulator, four LVAs in the aircraft, and eight LVAs in the simulator. He flew the most recent two LVA events on 6 April 2010. (Tab CC-3) The MCP stated that he was ready to fly combat missions on the date of the mishap. (Tab V-1.19)

The MCP had no overdue flying events and was cleared on the unit's go/no-go list on 8 April 2010. (Tab G-72) He had not signed off the four latest FCIF items on the unit's FCIF tracking sheet on 8 April 2010. (Tab K-19) The MC had no explanation for this, but did state that he was certain that the MCP was aware of the information contained in those four items. (Tab V-28.39)

Recent flight time is as follows: (Tab G-35, G-36, G-38)

	Hours	Sorties	Sim hours	Sim sorties
30 days	4.2	5	4.5	2
60 days	4.2	5	10.5	5
90 days	45.1	23	13.2	6

c. Mishap Flight Engineer

The MFE was a highly experienced evaluator flight engineer. He had 18 years of flying, a chief Airman aircrew member aeronautical rating and a total of 4,097 flight hours. (Tab G-40, G-45) In April 1993, he completed flight engineer training in the MH-53 at Kirtland AFB NM. (Tab G-164) He completed initial instructor upgrade in the MH-53 in October 1997. (Tab G-164) He completed initial training in the CV-22 in June 2007 and upgraded to instructor in October 2007. (Tab G-162) The MFE was certified as an evaluator flight engineer in August 2008. (Tab G-169) Fellow aircrew members described him as one of the most experienced and highly qualified flight engineers in the CV-22 community, respected by all as a senior NCO and a flight engineer. (Tab V-2.15, V-7.29, V-8.12, V-12.6, V-13.16, V-14.3, V-15.33, V-17.4, V-18.10, V-22.9, V-24.6 thru V-24.7, V-60.9)

The MFE flew during the February training exercise. (Tab G-51 thru G-53) The MFE completed the training for the new avionics software suite prior to deploying. (Tab V-7.23) He conducted three simulator predeployment training sorties, practicing mission representative scenarios with his hard crew, for a total of 7.5 hours. (Tab G-51, Tab V-69.1, V-70.1, V-71.1) During the unit spin-up period of 5-6 April 2010 after arriving in country, the MFE flew one sortie. (Tab AA-17, AA-23) On 7 April 2010, he flew a DV support sortie. (Tab AA-12) During the period of 1 January 2010 until the mishap, the MFE logged six NVG sorties in the aircraft, one NVG sortie in the simulator, three LVAs in the aircraft and three LVAs in the simulator. He flew the three most recent LVAs on 6 April 2010. (Tab CC-3)

According to the unit's go/no-go list on 8 April 2010, the MFE had no overdue training events. (Tab G-72) The MFE had not signed off the four latest FCIF items on the unit's FCIF tracking sheet on 8 April 2010. (Tab K-19) The MC had no explanation for this, but did state that he was certain that MFE was aware of the information in those four items. (V-28.39)

Recent flight time is as follows.[8] (Tab G-51 thru G-53)

	Hours	Sorties	Sim hours	Sim sorties
30 days	12.5	7	4.5	2
60 days	19.8	9	7.5	3
90 days	33.4	16	7.5	3

d. Mishap Tail Scanner

The MTS was a flight engineer with recent combat experience in the MH-53. He had almost four years of flying, a basic Airman aircrew member aeronautical rating and a total of 614 flight hours. (Tab G-58, G-63) In November 2006, he completed flight engineer training in the MH-53 at Kirtland AFB, NM. (Tab G-227) He completed initial training in the CV-22 in June 2009. (Tab G-225) Fellow aircrew members described him as a skilled flight engineer. (Tab V-2.15, V-28.1)

The MTS flew missions during both the January 2010 and February 2010 training exercises for a total of 11.4 hours and 24.0 hours, respectively. (Tab G-66 thru G-67) He completed the training for the new avionics software suite prior to deploying. (Tab V-7.23) He conducted two simulator predeployment training sorties, practicing mission representative scenarios with his hard crew for a total of 4.5 hours. (Tab G-66, G-67, Tab V-69.1, V-70.1, V-71.1) During the unit spin-up period of 5-6 April 2010 after arriving in country, the MTS flew two sorties. (Tab AA-12, AA-23) On 7 April 2010, he flew a DV support sortie. (Tab G-67, Tab AA-12) During the period of 1 January 2010 until the mishap, the MTS logged nine NVG sorties in the aircraft, one NVG sortie in the simulator, two LVAs in the aircraft, and six LVAs in the simulator. He flew the most recent LVA in the simulator on 19 March 2010 and before that in the aircraft on 23 February 2010. During the unit spin-up period, the MTS did not fly an LVA in the tail scanner position, and therefore could not log an LVA for currency. (Tab CC-3)

According to the unit's go/no-go list on 8 April 2010, the MTS had no overdue training events. (Tab G-72) The MTS had not signed off the four latest FCIF items on the unit's FCIF tracking sheet on 8 April 2010. (Tab K-19) The MC had no explanation for this, but did state that he was certain that the MTS was aware of the information contained in those four items. (Tab V-28.39)

Recent flight time is as follows.[9] (Tab G-68-71 thru G-71)

	Hours	Sorties	Sim hours	Sim sorties
30 days	8.3	6	4.5	2
60 days	12.6	7	7.5	3
90 days	55.4	28	10.5	5

[8] The sortie on 6 April 2010 was entered into the database twice resulting in a duplicate 2.2 hour sortie. The numbers in the table contain this error.

[9] The sortie on 6 April 2010 was not entered into the database although the MTS did fly that 2.2 hour sortie. (Tab AA-17) The numbers in the table contain this error.

9. MEDICAL

a. Qualifications

At the time of the mishap, the MCR were all medically qualified for flight duty without restrictions. (Tab X-3 thru X-4) Flight physical examinations (annual Preventive Health Assessments (PHA)) were current for all mishap crew members. (Tab X-3 thru X-4)

b. Health

The AIB medical member reviewed all available medical records, as well as witness testimony as to the health and personal well-being of the MCR. (Tab V-10.20, V-12.9, V-13.7, V-15.16, V-17.11, Tab X-3 thru X-4) Record review indicated that the MCR was in good health and had no performance-limiting condition or illness prior to the mishap. (Tab X-3 thru X-4)

There was no evidence that any medical condition contributed to the mishap.

Post-mishap medical records for the MCP and MTS were reviewed, revealing extensive injuries directly related to the mishap. (Tab X-3 thru X-4) All available post-mishap medical records for the surviving passengers were also reviewed, revealing extensive and varied injuries directly related to the mishap sequence of events. (Tab X-3 thru X-4)

c. Toxicology

Post-mishap toxicology specimens were not obtained from the MCP and MTS, as they were evacuated immediately post-mishap. Once stabilized, it was beyond the time window for valid testing.

Post-mortem toxicology specimens were obtained from the MP and MFE. AFIP examined these specimens for the presence of alcohol, amphetamine, barbiturate, benzodiazepine, cannabinoids, cocaine, opiates and phencyclidine as well as cyanides and carboxyhemoglobin (for carbon monoxide) and all results were negative. (Tab X-7, X-9)

d. Lifestyle

Interviews with the MCP, MTS and other squadron members familiar with the crew did not reveal any known medication use, medical issues or unusual personal stressors that may have affected the MCR on the night of the mishap. (Tab V-10.22, V-12.10, V-13.18, V-15.18, V-17.12) No lifestyle factors were found to be relevant to the mishap.

e. Crew Rest and Crew Duty Time

AFI 11-202, Volume 3, *General Flight Rules*, 5 April 2006 requires aircrew members have proper "crew rest," prior to performing in flight duties. (Tab BB-28 thru BB-30) AFI 11-202 defines normal crew rest as a minimum 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 the opportunity for at least eight hours of uninterrupted sleep. (Tab BB-28 thru BB-30)

Normal operations tempo for the 8 SOS at the time of the mishap involved 12-hour duty shifts (1445Z – 0245Z) on a rotational schedule. (Tab K-3) Crews would have an alert assumption brief at 1515Z. (Tab V-10.10) Four of the six crews were assigned flying duties and would rotate between three days of primary flight and one day of being the "spare" crew. The fifth crew was assigned Functional Check Flight (FCF) duties and the sixth crew worked in the Planning Operations Center (POC). These assignments would last for four days, and then the crews would rotate. (Tab K-3)

The MCR flew missions on 5 and 6 April 2010 and a DV support mission on the evening of 7 April 2010. (Tab AA-12 thru AA-26)

Crew rest and crew duty day do not appear to have been factors in this mishap.

10. OPERATIONS AND SUPERVISION

a. Operations

The MCR were all assigned to 8 SOS at Hurlburt Field, FL. The MP was a flight commander in the squadron. (Tab V-8.3) The MCP was the Chief of Mobility. (Tab V-2.12) The MFE was the senior enlisted manager of the squadron. (Tab V-18.10)

The operations tempo of the 8 SOS is high. The squadron stood up the CV-22 weapon system in August 2006. (Tab V-7.2 thru V-7.3, Tab II-12) Prior to this time, the 8 SOS was flying the MC-130E Talon I. (Tab V-7.2 thru V-7.3, V-10.2) Several of the crewmembers transitioned to the new weapon system, but the majority of crewmembers came from other rotary wing aircraft, primarily the MH-53. (Tab V-2.2, V-11.2, V-12.2, V-13.2, V-14.2, V-15.2, V-16.2, V-17.2, V-18.2, V-22.2, V-27.2, V-28.2, V-46.2, V- 60.2, V-62.2) In the four years leading up to the mishap, the unit had participated in operational test periods, stateside and overseas exercises up to 90 days long, and one combat deployment for 120 days in support of OIF ending in November 2009. (Tab V-2.6) The deployment in support of OEF started in March 2010. (Tab V-7.5, V-7.36, Tab II-12)

The time period between November 2009 and March 2010 was spent preparing for the OEF deployment. (Tab V-2.6 thru V-2.7) The unit deployed to two separate exercises in the southwestern U.S. in January and February 2010, both targeted at flying in an environment similar to the AOR. (Tab V-7.13) During these exercises, aircrews trained with Army personnel that they were designated to support in the AOR. (Tab V-2.7) Before deploying in March, the squadron executed a final training program in the simulator to build continuity as hard crews, become familiar with new avionics software, and practice flying mission scenarios in the simulator OEF database. (Tab V-70.1)

The deployed operations tempo was also high. Aircrews and maintainers met the ship containing the aircraft at a port in southwest Asia on or about 29 March 2010. (Tab V-2.7, V-28.28) The aircraft were unloaded, de-preserved and prepared for flight on 30 March 2010. (Tab V-2.7, V-23.8, V-28.28) On 1 April 2010, the aircraft were flown to the deployed location. (Tab

V-28.34) Maintenance personnel spent the next three days uploading the new avionics software and working other minor maintenance actions to prepare for flight operations on 5 April 2010. Maintenance reported to MC that they were ready for operations on 5 April 2010. (Tab V-2.22, V-25.10) From 5 to 6 April 2010, the squadron conducted flights to familiarize themselves with the AOR, practice aerial gunnery and refresh skills on LVAs. (Tab V-7.6, V-18.24, V-28.29) The daily familiarization flight schedule was 2, two-hour sorties followed by 2 more two-hour sorties. On the average, each crew was able to accomplish a minimum of one LVA and all flight engineers practiced shooting the .50 caliber machine gun on the local gun range. (Tab V-28.15 thru V-28.16) All crews stated that they felt ready to execute combat missions at the end of these two days. The MC deemed the unit ready after monitoring the spin up training period, although he did not remember if all the aircrew training objectives were accomplished. (Tab V-28.29) The MC reported to the TF CC on the night of 6 April 2010 that his unit was ready to receive and execute combat mission taskings beginning on 7 April 2010. (Tab V-28.29)

The squadron deployed with six fully qualified combat crews, each comprising an aircraft commander, a copilot, a lead (more experienced) flight engineer and a less experienced flight engineer. (Tab V-2.13) Three of these aircraft commanders were certified as flight leads. (Tab V-28.9) The duty schedule rotation afforded each crew time off only when FCF flights were not required. (Tab V-28.9 thru V-28.10, V-67.20)

A staggered crew rotation schedule allowed each crew to rotate out of the AOR before the end of the deployment. (Tab V-2.12 thru V-2.13) This provided for overlap to ensure continuity and maintained flight lead experience to support the missions. (Tab V-2.13)

On 7 April 2010, the first CV-22 combat mission in the Afghanistan AOR occurred. (Tab V-15.5, V-17.5, V-27.14) The MCR flew a DV mission that day. (Tab R-50, Tab AA-12) On 8 April 2010, the MCR was designated as the flight lead crew. (Tab V-10.29, V-45.2, V-67.21, Tab AA-12) They showed for duty at the normal time of 1445Z and launched on a mission approximately three hours later. (Tab V-1.19) They flew 0.5 hours on the first sortie from MOB1 to the FOB, prior to taking off on the mishap sortie. (Tab V-67.1 thru V-67.4, Tab AA-12)

There is no evidence that the operations tempo contributed to the mishap.

b. Supervision

The 8 SOS leadership, MC and DO, are both senior aviators. They communicated daily and described an excellent working relationship. (Tab V-2.17, V-28.11) Aircrews at home station were kept well informed on deployed operations, thus allowing them to better prepare for their future rotations to the AOR. (Tab V-28.9)

The 8 SOS supported TF CC with oversight from JSOAD. (Tab V-2.19 thru V-2.20) LNOs were present to facilitate communication between the organizations. (Tab V-2.12) MC, TF CC, and JSOAD described an effective organizational relationship. (Tab V-38.6)

The MC was intimately involved with the mission planning at all levels. He reviewed the ORM worksheet provided by MCR and assessed it at the higher portion of "medium" and approved the mission with no further requirement for a higher level approval. (Tab V-28.26 thru V-28.27) The MC provided guidance to his aircrew regarding the risk of the missions in this AOR. He explained that you "never sacrifice mission accomplishment to try and get in the LZ the first time or to try and meet a standard or salvage an approach. If you need to go around, you go around and you get the team in safely first and foremost and get them out safely." (Tab V-28.10) His guidance was fully understood by all the aircraft commanders. (Tab V-10.13, V-24.15, V-28.10)

The 8 SOS was using a unique command structure during this deployment. (Tab V-2.19 thru V-2.20) The maintenance personnel were placed under the MC. (Tab V-58.3) There is no evidence to suggest that the deployed supervision contributed to the mishap.

11. HUMAN FACTORS

a. Overview

Possible Human Factors contributing to the reported mishap were evaluated using the DoD Human Factors Analysis and Classification System (DoD-HFACS). (Tab BB-3 thru BB-26) The DoD-HFACS describes four main tiers of factors that may contribute to a mishap. From most specific (applied to an individual) to most general they are: Acts, Pre-Conditions, Supervision, and Organizational Influences. (Tab BB-3, BB-6, BB-20, BB-23) These categories and individual factors are described in detail below.

After reviewing the facts of the investigation, including witness testimony, human factors believed to possibly be present in this mishap are enumerated below, together with the DoD-HFACS taxonomy (or "nanocodes") for reference. (Tab BB-3 thru BB-26)

It should be noted the MP and MFE suffered fatal injuries at the time of the impact, leaving only the MCP as the surviving cockpit crew member. (Tab X-3 thru X-4) As a result of his injuries, the MCP appears to have suffered amnesia concerning the events immediately surrounding the impact. (Tab V-67.4, V-67.6) The MTS was stationed at the back of the mishap aircraft and, although on the intercom system (ICS), he was not directly aware of all of the flight parameters. (Tab V-60.27) Due to these factors and the lack of a recovered FIR, substantive facts to support human factors relevant to this mishap are extremely difficult to obtain. (Tab V-28.18) As a result, there is considerable extrapolation below as to possible factors relating to two alternative mishap scenarios.

b. Acts

Acts are those factors that are most closely tied to the mishap, and can be described as active failures or actions committed by the operator that result in human error or unsafe situations. (Tab BB-3)

Errors (AExxx) are factors in a mishap when mental or physical activities of the operator fail to achieve their intended outcome as a result of skill-based, perceptual, or judgment and decision making errors leading to an unsafe situation. Errors are unintended. (Tab BB-3)

1. AE105 Breakdown in Visual Scan -- Breakdown in Visual Scan is a factor when the individual fails to effectively execute learned/practiced internal or external visual scan patterns leading to an unsafe situation. (Tab BB-3 thru BB-4)

It is documented that the MA, during the final phases of flight, continued a vertical descent rate at higher than expected ground speed. (Tab L-4, Tab J-21 thru J-22, Tab JJ-3 thru JJ-4) This occurred at a point when a level altitude should have been flown in accordance with standard LVA procedures. (Tab V-7.17, Tab BB-31) There is no direct evidence, but it is possible that the MCR, in not performing an effective visual scan, to include internal instrumentation, lost track of the aircraft's vertical velocity. This could have resulted in a lack of control input to counter the descent and subsequent unexpected ground contact.

2. AE201 Risk Assessment – During Operation -- Risk Assessment – During Operation is a factor when the individual fails to adequately evaluate the risks associated with a particular course of action and this faulty evaluation leads to an inappropriate decision and subsequent unsafe situation. This failure occurs in real-time when formal risk-assessment procedures are not possible. (Tab BB-4)

There is evidence that winds at the LZ differed considerably from the crew's original brief of light and variable, to approximately 17 knots of quartering tailwind. (Tab V-10.26, V-15.7, V-17.6) By SOP and aircraft limitations, the maximum acceptable tailwinds for landing are 10 knots, although there is individual variation by pilot, depending on weight, altitude, temperature, and available power. (Tab V-7.18, V-7.29, V-10.18, V-15.8, V-28.10 thru V-28.11) There is no direct evidence, but it is possible that the crew, aware of the excess tailwinds, made the decision to continue the approach into a situation where tailwinds, available power, weight, and altitude created an unsafe landing condition.

3. AE204 Necessary Action – Delayed -- Necessary Action – Delayed is a factor when the individual selects a course of action but elects to delay execution of the actions and the delay leads to an unsafe situation. (Tab BB-4)

In the case of an inadequate power situation, or unfavorable winds or landing environment, the accepted practice is to execute a "go-around" and re-accomplish the approach or at least to re-assess for adequate power and landing condition. There is evidence that the MA was travelling at excessive speed for the phase of approach in the mission profile. (Tab L-4, Tab J-21 thru J-22, Tab JJ-3 thru JJ-4) There is no direct evidence, but it is possible that the MCR realized that the approach conditions were not optimal or that there was insufficient power to land. Therefore, the MCR decided to execute a "go-around" but the decision was made too late in the sequence of events for the action to be successful.

4. AE205 Caution/Warning – Ignored -- Caution/Warning – Ignored is a factor when a caution or warning is perceived and understood by the individual but is ignored by the individual leading to an unsafe situation. (Tab BB-4)

CHK1B heard a "Low Altitude" computerized voice warning over the MA's ICS, and described it as a warning heard routinely on SOF aircraft during low-level flight. (Tab R-26, Tab V-20.6 thru V-20.7) In the CV-22, this particular warning is only heard when the terrain following (TF) radar system is active or the approach mode is active, and indicates a critical flight condition. (Tab V-1.9) The TF system was de-activated well before events in the mishap sequence. (Tab V-1.8) The only other voice warnings that were heard occurred upon or just after impact. (Tab V-60.23, V-60.40) Although the radar altimeter low altitude warning beeps began to sound below the radar altimeter low set point (80 feet), only the MTS recalled hearing this, and he was not sure of the timing. (Tab V-60.20 thru V-60.21, V-67.4) There is no evidence that the MCR ignored a Caution/Warning that was perceived and understood in time to react.

5. AE206 Decision-Making During Operation -- Decision-Making During Operation is a factor when the individual through faulty logic selects the wrong course of action in a time-constrained environment. (Tab BB-4)

The MA had a higher airspeed/groundspeed than would be expected in the final phases of flight, specifically greater than 100 KGS while less than one-half mile from the LZ. (Tab L-4, Tab JJ-3 thru JJ-4) There was a tailwind component of 17 knots on final approach. (Tab V-15.7, V-17.6) There is no direct evidence, but it is possible that the MCR, on noticing this excessive speed and tailwind, made the decision to continue the approach. This decision would have represented faulty logic and the wrong course of action as an attempt to continue the landing to the LZ with this tailwind would be unsafe and beyond the aircraft's limits. (Tab V-7.18, V-29.24)

It is also possible that the MCR made the decision to go-around at this point, but did not have the altitude or power necessary to accomplish this maneuver with the descent rate established. In this case, the MCR would have selected the correct course of action, but were unable to accomplish it. If MCR decided to go-around, Decision-Making During Operation was not a factor.

Violations (AVxxx) are factors in a mishap when the actions of the operator represent willful disregard for rules and instructions and lead to an unsafe situation. Violations are deliberate. (Tab BB-5) No violations were found to be present in this mishap, as none of the actions discussed above or below were considered to be intentional decisions to disregard instructions.

c. Preconditions

Preconditions are factors in a mishap if active and/or latent preconditions such as conditions of the operators, environmental or personnel factors affect practices, conditions or actions of individuals and result in human error or an unsafe situation. (Tab BB-6)

Environmental Factors (PExxx) are factors in a mishap if physical or technological factors affect practices, conditions, and actions of an individual and result in human error or an unsafe situation. (Tab BB-6)

1. PE102 Vision Restricted By Meteorological Conditions -- Vision Restricted by Meteorological Conditions is a factor when weather, haze, or darkness restricted the vision of the individual to a point where normal duties were affected. (Tab BB-6)

The night of the mishap was extremely dark. The MCP and the crews of the other two chalks described the low level of illumination, complicated by a suspended haze that effectively obscured the horizon and reduced the perception of terrain features. (Tab R-3, R-7, R-8, R-11, R-12, R-16, R-65, Tab V-10.5 thru V-10.6) It is very likely that, had visibility been better, the MCR could have utilized the improved visual cues to help with altitude, descent rate and airspeed during the approach.

2. PE109 Lighting of Other Aircraft/Vehicle -- Lighting of Other Aircraft/Vehicle is a factor when the absence, pattern, intensity or location of the lighting of other aircraft/vehicle prevents or interferes with safe task accomplishment. (Tab BB-7)

Statements made by the MCP suggested that he perceived an LZI pattern that was not consistent with his expectations:

> "I saw the illumination you were talking about, there were two of them. I've never seen that before and I know that the two circles of light were not together. There was one here and one here, they were both from what I could see, pretty much on the LZ but one or both of them were little off which was confusing at first why there were either two aircraft or two different--why there were two. That threw me off a little bit." (Tab V-1.10)

It is possible that this unexpected LZI pattern distracted the MCP, interfering with his ability to assist the MCR with safe aircraft handling during the final minute of flight. See also PC106 below.

3. PE111 Brownout/Whiteout -- Brownout/Whiteout is a factor when dust, snow, water, ash or other particulates in the environment are disturbed by the aircraft, vehicle or person and cause a restriction of vision to a point where normal duties are affected. (Tab BB-7)

Although brownout is a frequent phenomenon in CV-22 LZ operations, the forward velocity of the MA until touchdown did not allow this condition to occur. (Tab V-1.18, V-60.10, Tab Z-27)

Technological Environment (PE2xx) are factors in a mishap when cockpit/vehicle/control station/workspace design factors or automation affect the actions of individuals and result in human error and an unsafe situation. (Tab BB-7)

4. PE201 Seating and Restraints -- Seating and Restraints 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-7)

It is standard practice in the SOF community to "floor load" personnel rather than use the aircraft's designed internal seats. This is due to the normal aircraft seats being unable to accommodate SOF team members while fully equipped with body armor, helmets, weapons, and other required gear. (Tab V-2.3 thru V-2.4, V-7.3 thru V-7.4, V-20.13 thru V-20.14) The 8 SOS made a decision to remove the seats for operational missions based on SOF customer request. The "floor loaded" troops secure to the airframe with restraint devices that are designed solely to keep the troops from being ejected from the aircraft in flight or under normal landing conditions, and have no capability to protect personnel from crash forces. (Tab V-4.18, Tab BB-58) The use of the crashworthy seats could have possibly reduced some of the injuries sustained by the passengers. (Tab EE-29, EE-38)

5. PE208 Communications – Equipment -- Communications - Equipment is a factor when communication equipment is inadequate or unavailable to support mission demands (i.e. aircraft/vehicle with no intercom). This includes electronically or physically blocked transmissions. Communications can be voice, data or multi-sensory. (Tab BB-8)

The CV-22 has had continuing issues with communications equipment for some time. (Tab V-2.6, V-10.3) On the night of the mishap, there were multiple problems with radio communications. (Tab V-1.20, V-15.10, Tab II-13 thru II-14) The MP, upon takeoff, was unable to successfully communicate his takeoff time to the JOC. (Tab II-13 thru II-14) There is no direct evidence, but it is possible that the radio issues and repeated attempts to establish communications during the last minutes of flight could have been an additional element contributing to crew cognitive task load. See also PC103 below.

Condition of Individuals (PCxxx) are factors in a mishap if cognitive, psycho-behavioral, adverse physical state, or physical/mental limitations affect practices, conditions or actions of individuals and result in human error or an unsafe situation. (Tab BB-8) No Condition of Individual factors were found to be relevant to this mishap.

Cognitive Factors (PC1xx) are factors in a mishap if cognitive or attention management conditions affect the perception or performance of individuals and result in human error or an unsafe situation. (Tab BB-9)

6. PC103 Cognitive Task Oversaturation -- Cognitive Task Oversaturation is a factor when the quantity of information an individual must process exceeds their cognitive or mental resources in the amount of time available to process the information. (Tab BB-9)

The MA was too fast for approach profile during the final phases of flight and there were tailwinds higher than acceptable for landing. (Tab L-4, Tab J-21 thru J-22, Tab V-15.7, V-17.6) This was complicated by the communications issues described above (PE208) and the fact that the MCR would have to make landing or go-around decisions for the entire formation. While there is no direct evidence, it is possible that all these factors task-saturated the MCR (most notably MP) in the limited time from the DP to impact. This may have caused them to make inappropriate decisions or inappropriately delay decisions necessary to prevent the mishap.

There is no direct evidence of an aircraft malfunction, but any malfunction inside the one minute call could have added to cognitive task oversaturation experienced by the crew.

7. PC105 Negative Transfer -- Negative Transfer is a factor when the individual reverts to a highly learned behavior used in a previous system or situation and that response is inappropriate or degrades mission performance. (Tab BB-9)

There was a new software update to the CV-22 systems just prior to active use on this deployment. (Tab V-2.8) One of the new features of this software was an increase in cruising speed while in airplane mode. A familiar TCL setting for a specific airspeed would now result in a higher air speed. (Tab V-2.8, Tab II-6, Tab JJ-51 thru JJ-52) The MA was at an excessive speed in the final phases of flight. (Tab L-4, Tab J-21 to J-22, Tab Z-27) There is no direct evidence, but it is possible that the MP reverted to learned behavior from numerous missions in the CV-22 prior to the software update, resulting in a higher speed during the approach to the LZ. The MCP also exhibited negative transfer during the approach to the LZ. He had a tendency to continually crosscheck outside the aircraft due to his numerous hours flying other rotary wing aircraft that were primarily visual flight rules type platforms. (Tab G-31) The MCP admitted that his attention to monitoring instruments during the approach was disrupted due to crosschecking outside the aircraft during a critical phase of flight. (Tab V-67.26)

8. PC106 Distraction -- Distraction is a factor when the individual has an interruption of attention and/or inappropriate redirection of attention by an environmental cue or mental process that degrades performance. (Tab BB-9)

The MCP described an unexpected pattern with the LZI and described that it diverted his attention from the aircraft. (Tab V-1.9, V-67.27, see PE109 above) It is possible that this distracted his attention from providing appropriate Cross-Monitoring (see PP102 below) during the final two minutes of flight.

There is no direct evidence, but it is also possible that an aircraft malfunction during the final minute of flight could have caused a significant distraction to the entire cockpit crew (MP, MCP, MFE).

9. PC207 Pressing -- Pressing is a factor when the individual knowingly commits to a course of action that presses them and/or their equipment beyond reasonable limits. (Tab BB-11)

The MA's speed exceeded the normal deceleration profile speed and there was a 17 knot quartering tailwind. These conditions would likely have exceeded the landing capability of the aircraft to land at the LZ, on time, and from that heading. (Tab J-21 thru J-22, Tab L-4, Tab V-15.7, V-17.6, Tab Z-27) No communication calls were made on the ICS, interplane or FIRES indicating that the MA was executing a "go-around." It is possible that the MCR made a conscious decision to proceed with the approach and landing under these conditions, even though a "go-around" was the safe course of action.

10. PC504 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. (Tab BB-16)

The normal flight profile for the MA in the final phases of flight would involve a descent to 100-200 feet AGL, a level deceleration until approximately 0.15 nm from the LZ, and 20 to 30 KGS. Then the aircraft would descend to the ground for landing. (Tab V-17.6, Tab BB-31) During the deceleration, the MA continued to descend until impacting the ground 0.23 nm from the LZ. (Tab J-21 thru J-22, L-4, Tab Z-5, Tab JJ-3 thru JJ-4) While there is no direct evidence, it is possible that the MCR did not perceive the continued rate of descent and altitude loss, believing they were still in level flight. This misperception would result in the MCR failing to apply proper control inputs to stop their descent.

There is evidence that winds at the LZ differed considerably from the crew's original brief of light and variable to approximately 17 knots of quartering tailwind. (Tab V-10.25, V-15.3, V-15.7, V-17.6) By SOP and aircraft limitations, the maximum acceptable tailwinds for landing are 10 knots, although there is individual variation by pilot, depending on weight, altitude, temperature, and available power. (Tab V-7.18, V-7.29, V-10.18, V-15.89, V-28.11 thru V-28.12) There is no direct evidence, but it is possible that the MCR failed to perceive this tailwind (using their instruments), believing the winds to be within limits. This misperception could have caused them to continue on the landing profile.

11. PC506 Expectancy -- Expectancy is a factor when the individual expects to perceive a certain reality and those expectations are strong enough to create a false perception of the expectation. (Tab BB-16)

In his testimony, the MCP describes:

> "The last gate that I called out, we were 0.4 or 0.42, somewhere in there and we were 43 or 45 knots, so we were basically right where we needed to be. We should be 0.4, 40 knots; 0.3, 30 knots, etc. You are gradually slowing down as you are getting closer to the LZ. That was the last gate I remember calling out." (Tab V-1.11)

According to normal operational procedures, this would have been on profile. (Tab V-7.16) The MA was considerably faster at the 0.4 mile mark and up to and including the time of impact. (Tab L-4, Tab Z-27, Tab JJ-3 thru JJ-4) If this memory is accurate, then it is possible that the MCP was experiencing Expectancy, and this would result in his not giving corrective input to the rest of the MCR.

12. PC508 Spatial Disorientation (Type 1) Unrecognized -- 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. Spatial Disorientation (Type 1) Unrecognized is a factor when a person's cognitive awareness of one or more of the following varies from reality: attitude, position, velocity, direction of motion or acceleration. Proper control inputs are not made because the need is unknown. (Tab BB-16)

This factor is directly related to any Misperception of Operational Conditions (PC504 above). If the MCR did not properly perceive a gradual rate of descent, and they perceived themselves to be in level flight, they would not have realized a need to perform corrective control inputs. There is some inconclusive evidence that the MCR may have realized their actual position in the final seconds of flight, but may have been indecisive or unable to apply proper control inputs in the extremely limited time available. (Tab V-1.10, Tab V-60.26, V-60.32) In testimony, the MTS described a sudden awareness of ground proximity that is consistent with not being aware of rate of descent, and thus a sense of Spatial Disorientation. (Tab V-60.32) There is no definitive evidence for this scenario.

Personnel Factors (PPxxx) are factors in a mishap if self imposed stressors or crew resource management affect practices, conditions or actions of individuals and result in human error or an unsafe situation. (Tab BB-17)

13. PP102 Cross-Monitoring Performance -- Cross-Monitoring Performance is a factor when crew or team members failed to monitor, assist or back-up each other's actions and decisions. (Tab BB-17)

The MTS stated that his primary focus was on scanning for enemy activity and assuring the safety of the passengers. (Tab V-60.4, V-60.10) The MTS did not remember calling "stop down" or "go-around" as the aircraft rapidly descended to the ground. There is also some evidence that the MCP may have been distracted or suffering from expectancy. (See PC106 and PC506 above) It is possible that these factors may have degraded Cross-Monitoring Performance within the MCR. (See PP110 below)

14. PP110 Mission Briefing -- Mission briefing is a factor when information and instructions provided to individuals, crews, or teams were insufficient, or participants failed to discuss contingencies and strategies to cope with contingencies. (Tab BB-18)

Due to the alert posture of the unit, the MCP, MFE, and the MTS did not attend the initial mission brief at MOB1. During this briefing, there is a detailed discussion of the entire LZ operation phase of the mission. At the FOB, the MCP and the MTS did not attend the AMB accomplished by MP, MFE and the Army team leadership. (Tab V-10.11, V-15.4, V-17.3) Instead, per unit SOP, the MCP and the MTS were briefed at the aircraft just prior to launch from the FOB. The MCP was not aware of all the details of the LZI plan after this briefing. (Tab V-67.15) It is not clear if the MCP and the MTS were fully aware of all relevant mission details. (Tab V-67.15) During debrief of the 7 April 2010 mission, the unit noted that some specific items needed to be added to mission briefings. (Tab V-10.9)

d. Supervision

Supervision is a factor in a mishap if the methods, decisions or policies of the supervisory chain of command directly affect practices, conditions, or actions of individuals and result in human error or an unsafe situation. (Tab BB-20)

Inadequate Supervision (SIxxx) is a factor in a mishap when supervision proves inappropriate or improper and fails to identify hazards, recognize and control risk, provide guidance, training and/or oversight, and results in human error or an unsafe situation. (Tab BB-20)

1. SI003 Local Training Issues/Programs -- Local Training Issues/Programs are a factor when one-time or recurrent training programs, upgrade programs, transition programs or any other local training is inadequate or unavailable (etc) and this creates an unsafe situation. (Tab BB-20)

Prior to deployment, the unit participated in two CONUS training deployments with similar environmental conditions, profiles, and ground force units as those in the deployed location. (Tab V-28.5) After arrival in the AOR, the unit conducted spin-up missions. These missions were designed to refresh skills on LVAs and gunnery, to become familiar with the actual operational environment and to "shake the rust off." (Tab V-7.5, V-10.9, V-18.24) The predeployment and familiarization training was adequate. All crew members felt prepared to execute combat missions beginning on 7 April 2010. (Tab V-17.5, V-22.6, V-29.7)

e. Organizational Influences

Organizational influences are factors in a mishap if the communications, actions, omissions or policies of upper-level management directly or indirectly affect supervisory practices, conditions or actions of the operator(s) and result in system failure, human error or an unsafe situation. (Tab BB-23) No Organizational Influences were found relevant to this mishap.

Review of the DOD-HFACS, witness testimony, and medical records revealed no other human factors as contributory to this mishap. (Tab V-1.18, V-10.22, V-15.18, V-28.10 thru V-28.11, V-60.9, Tab X-1 thru X-12, Tab BB-3 thru BB-26)

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Primary Operations Directives and Publications

(1) AFI 11-202, *Volume 1, Aircrew Training*, dated 17 May 2007
(2) AFI 11-202, *Volume 2, Aircrew Standardization/Evaluation Program*, dated 19 September 2007
(3) AFI 11-202, *Volume 3, General Flight Rules*, dated 5 April 2006
(4) AFI 11-401, *Aviation Management*, dated 7 March 2007
(5) CV-22 Operations CONOPS, *Annex A, Flying Operations – CV-22 Aircrew Training*, dated 1 April 2008

(6) CV-22 Operations CONOPS, *Annex B, Flying Operations – CV-22 Evaluation Criteria*, dated 13 January 2006
(7) CV-22 Operations CONOPS, *Annex C, Flying Operations – CV-22 Operations Procedures*, dated 21 February 2008
(8) AFSOCH 11-222, *Combat Aircraft Fundamentals – CV-22*, dated 1 September 2004
(9) TO 1V-22(C)B-1, *Flight Manual, USAF Series, CV-22B Tiltrotor*, dated 15 October 2008
(10) TO 1V-22(C)B-1CL-1, *Pilot/Engineer Pocket Checklist, USAF Series, CV-22B Tiltrotor*, dated 1 January 2007
(11) TO 1V-22(C)B-1-1, *Flight Manual Performance Data, USAF Series, CV-22B Tiltrotor*, through Change 1, dated 16 March 2009
(12) A1-V22AC-AFM-000, *Preliminary NATOPS Flight Manual USAF Series CV-22 Tiltrotor*, dated 15 September 2008
(13) A1-V22AB-NFM-000, *NATOPS Flight Manual Navy Model MV-22B Tiltrotor*, dated 30 September 2009
(14) TO 1V-22(C)B-5-1, *CV-22 Sample Basic Weight Checklists and Loading Data, USAF Series CV-22 Tiltrotor*, dated 1 September 2008
(15) 8 SOS SOP, *Standard Operating Procedures*, dated 4 January 2010

b. Maintenance Directives and Publications

(1) AFI 21-101, *Aircraft and Equipment Maintenance Management*, dated 29 June 2006
(2) AFI 21-101, Air Force Special Operations Command Supplement, *Maintenance – Aircraft and Equipment Maintenance Management*, dated 21 August 2009
(3) AFI 21-101, 1 SOMXG Supplement 1, *Maintenance –Aerospace Equipment Maintenance Management*, dated 1 February 2010
(4) TO 1V-22(C)B-761, *Inspection/TCTO Planning Checklist*, dated 26 February 2010
(5) TO 00-5-15, *Technical Manual Air Force Time Compliance Technical Order Process*, dated 1 January 2010
(6) TO 00-20-1, *Technical Manual Aerospace Equipment Maintenance Inspection, Documentation, Policies, and Procedures*, dated 1 September 2006
(7) TO 1V-22(C)B-2-DB-1, *V-22 Technical Information System, Organizational, Intermediate, and Depot Maintenance*, dated 16 November 2009
(8) TO 1V-22(C)B-6, *Inspection Requirements Manual, USAF Series, CV-22B Aircraft*, dated 1 March 2010

c. Known or Suspected Deviations from Directives or Publications

Other than the maintenance deviations mentioned in Section 5 above, there are no known or suspected deviations from directives or publications by crew members or others involved in the mishap mission.

13. NEWS MEDIA INVOLVEMENT

Media attention to the mishap was substantial. Several media outlets, blogs and trade journals carried stories about the mishap. (Tab EE-50 thru EE-63) These articles highlighted that this was the first combat loss of a V-22. (Tab EE-55, EE-59 thru EE-60) Post-mishap, several articles speculated as to the cause. Initially, Popular Mechanics reported that the cause was brownout conditions. (Tab EE-57) Flight International stated that the cause of the crash was not mechanical, but instead brown-out conditions, citing an unnamed source familiar with the preliminary investigation. (Tab EE-56) On 18 May 2010, the Line of Departure website, along with WTOP, a Washington D.C. radio station, reported that the cause of the mishap was pilot error. (Tab EE-56 thru EE-60) Specifically, they alleged "the pilot flew too low in airplane mode when its blades struck an earthen berm, shearing off the wings and flipping it over."

Other media attention has mentioned the mishap while focusing on other issues with the V-22. (Tab EE-27, EE-29, EE-32)

14. ADDITIONAL AREAS OF CONCERN

The disposition of the wreckage cited in Tab H-4 and H-5 are incorrect. After the MA was destroyed, the battlespace owner went to the mishap site, took photographs and further destroyed some pieces of the wreckage. (Tab II-5) Several days later, they loaded the remainder of the wreckage onto flat bed trucks and took it to FOB Apache. During interviews in Afghanistan, the AIB learned of the existence of this wreckage. On 27 May 2010, the PM, MXM, and the ALA flew to FOB Apache to secure the wreckage. On 19 June 2010, a maintenance team was onsite in Afghanistan to provide further analysis of that wreckage. They shipped the left engine back to the manufacturer Rolls Royce in July 2010 for analysis. That analysis was completed on 24 July 2010.

Donald D. Harvel

25 August 2010

DONALD D. HARVEL
Brigadier General, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

CV-22B, T/N 06-0031
9 APRIL 2010 (L)

1. STATUTORY LIMITATIONS

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

2. OPINION SUMMARY

a. Background:

On 8 April 2010* at 1805Z/2235L the mishap aircraft (MA), a CV-22B, tail number (T/N) 06-0031, deployed with the 8th Special Operations Squadron (8 SOS), took off as the lead aircraft of a three-ship formation from Main Operating Base 1 (MOB1). (Tab V-10.3, V-15.6, Tab AA-9, Tab JJ-19) After an uneventful flight, the formation landed at a forward operating base (FOB) at 1835Z. (Tab V-60.3, Tab AA-9) At the FOB, the mishap crew (MCR) loaded 14 Army personnel and two civilians and departed at 1956Z for a routine infiltration mission. (Tab K-8, Tab R-71, R-74, Tab AA-9, Tab JJ-3) Even though the MCR was using night vision goggles appropriately, visibility was still reduced near the landing zone (LZ) due to dust, haze, zero lunar illumination, and the lack of cultural lighting. (Tab R-60, R-65, Tab V-1.17, V-10.5) The MCR encountered intermittent aircraft radio problems during the en route portion of the flight. (Tab R-59, Tab V-10.3, V-25.4) After the first waypoint, the mishap copilot (MCP) transferred the aircraft controls to the mishap pilot (MP). (Tab V-1.5) The MCR was more than one minute late for the time on target (TOT). (Tab JJ-3 thru JJ-4) During the descent, the MA attained speeds up to 274 knots ground speed (KGS), which was faster than the planned 240 KGS. (Tab L-4, Tab JJ-3 thru JJ-4) At the initial point (IP), the MCR was still 55 seconds late for the TOT. Between the IP and the deceleration point (DP), the winds changed from light and variable to an approximately 17 knot tailwind from the east. (Tab F-3, Tab R-60, R-64, R-80, Tab V-10.18, V-13.25, V-17.6, Tab W-13, Tab II-12) The MA crossed the DP at 300 feet above ground level (AGL) and approximately 230 knots calibrated airspeed (KCAS)/270 KGS. (Tab L-4, Tab JJ-4) The MP began decelerating at 2.5 nautical miles (nm) from the LZ, instead of the standard 3 nm. (Tab L-4, Tab BB-31, Tab JJ-4) As the MA slowed, the MP started a descent to 100 feet AGL. (Tab L-4, Tab JJ-4) A member of the MCR relayed the "one minute" call to the MA's passengers. (Tab V-4.9, V-4.24, V-19.4, V-66.3) The MA then slowed rapidly as the nacelles were rotated towards the helicopter position. (Tab L-4, Tab V-6.7, V-10.19, Tab JJ-4) At 1 nm from the LZ, the MCR was on time for the TOT. (Tab JJ-4) However, the MA was at 200 KGS instead of the standard 110 KGS. (Tab R-26, Tab V-19.4, V-20.3, V-20.7, V-21.2 thru

* The crash occurred at 2009 Zulu (Z) on 8 April 2010, which was 0039L on 9 April 2010 in Afghanistan.

V-21.3, V-23.12 thru V-23.13, Tab BB-31, Tab JJ-4) At 0.79 nm from the LZ, the MA's speed was approximately 147 KCAS/178 KGS and their altitude was 150 feet AGL. (Tab JJ-4) The normal speed at that point should have been approximately 80 to 90 KGS. (Tab BB-31) At 0.5 nm from the LZ, the MA had slowed to 128 KGS. (Tab JJ-4) The normal speed should have been 60 to 70 KGS. (Tab BB-31) A very excited discussion occurred in the cockpit seconds prior to impact. (Tab V-60.28, V-60.34) A member of the MCR counted down "10, 9, 8, 7" rapidly and at "7" the aircraft impacted the ground. (Tab V-20.4) The mishap tail scanner (MTS) also indicated that shortly after impact, he heard several aircraft computer generated voice warnings. (Tab V-60.22)

At 2009:15Z and 0.23 nm from the intended LZ, the MA impacted the ground at approximately 75 KGS with less than 14 degree nose-up pitch attitude. (Tab HH-31) The MA's wings were nearly level and the nose wheel was nearly centered. (Tab Z-3, Z-5, Tab HH-25, Tab JJ-4) The MA rolled on its landing gear across the sand for approximately 45 feet leaving marks indicative of a nearly perfect roll-on landing. (Tab Z-3, Z-25) Soon after touchdown, the nose gear collapsed. (Tab V-48.3, Tab Z-25) The nose of the aircraft then began to plow into the sand. After sliding approximately 15 feet, the nose of the aircraft impacted a two-foot deep natural drainage ditch, causing the MA to flip tail over nose. At 2009:20Z, parts of the MA exploded. (Tab Z-27) The MA came to rest at 2009:22Z, with the cockpit collapsed and nearly severed. (Tab R-23, R-24, Tab S-3, S-4, Tab V-4.11) The cockpit folded back under the roof of the aircraft as the MA came to rest on its back, facing approximately 170 degrees from the initial direction of travel.

b. Causation

After a thorough, careful and complete investigation, I ruled out multiple causes including: enemy action, brownout, vortex ring state, mid-air collision, loss of hydraulic system, electrical failure, drive shaft failure, swashplate actuator mount failure, flight control failure, thrust control lever (TCL) rigging, avionics failure, and crew physiological events. I analyzed the testimony from over ninety interviews, conducted aerial analysis of the crash site, visited the main and forward operating bases, consulted with subject matter experts, thoroughly examined MCR's training records and all applicable publications, viewed and analyzed photographs and videos of the mishap, analyzed the data transfer module contents, and flew the exact mission profile for over 18 hours in the CV-22 simulator (with and without aircraft malfunctions). (Tab A thru Tab JJ)

I was unable to determine, by clear and convincing evidence, the cause of this mishap. Clear and convincing evidence is a determination, without serious or substantial doubt, where the evidence shows that it is highly probable that the conclusion is correct. I determined by a preponderance of the evidence that ten factors substantially contributed to this mishap. Preponderance of the evidence is the greater weight of credible evidence, which when fairly considered, produces the stronger impression. This evidence is more convincing as to its truth when weighed against the opposing evidence. These 10 substantially contributing factors fall into one of four categories: mission execution, environmental conditions, human factors and aircraft performance.

c. Substantially Contributing Factors

(1) Mission Execution

Inadequate weather planning During mission planning, the crews did not seek out easily obtainable and specific weather data for the LZ and surrounding FOBs. (Tab V-28.3, V-28.19, V-28.29 thru V-28.30, Tab W-5) The general weather data obtained by the mission planners at MOB1, and provided to the three mission aircraft commanders that night, described the winds as light and variable. (Tab F-3) As a result, the mission was planned for an east to west run-in to the LZ. (Tab JJ-19 thru JJ-39) More specific weather data would have led the mission planners to choose a run-in heading that accounted for the forecast easterly winds at 10 to 15 knots. (Tab W-5) It is more likely than not that the actual winds encountered near the DP surprised the MCR during this critical phase of flight.

Poorly executed low visibility approach (LVA) The data transfer module (DTM) data provided irrefutable evidence that the MP managed the TOT poorly and flew a nonstandard approach profile. (Tab JJ-3 thru JJ-4) The MP responded to this situation by performing a rapid conversion for landing. The greater weight of credible evidence indicates the MP applied aggressive control inputs to slow down and maintain altitude. These control inputs, made in an attempt to salvage the poor approach, played an important role in the sequence of events and tasks that the MCR had to address in the last mile prior to the LZ.

(2) Environmental Conditions

Tailwind Near the DP, the right quartering wind, that translated to an approximately 17 knot tailwind, impeded the slowdown of the MA. (Tab V-15.20, V-16.4, Tab JJ-4) It is more likely than not that the MCR became aware of this tailwind at some point during the approach. However, the unexpected wind complicated the execution of the approach by pushing the MA to the left of course centerline. It added to the MCR's task saturation and reduced available time for critical decision making. This tailwind added to the ground speed of the MA at touchdown, thus increasing the damage and injuries that occurred during the crash sequence.

Challenging visual environment The low illumination, described by pilots as a "varsity night," decreased normal peripheral vision, depth perception and visual acuity. (Tab R-6 thru R-7, Tab V-67.23) This required the MP and MCP to rely on instrument flying more extensively. Flying an approach on instruments inherently requires more focused attention and processing time. The risk assessment associated with these challenging conditions was properly mitigated during mission planning. (Tab V-28.42 thru V-28.43) A preponderance of the evidence supports the conclusion that the challenging visual environment was a substantially contributing factor in preventing the MCR from initially noticing the descent rate.

(3) Human Factors

Task saturation During the final phase of the approach, the MCR needed to accomplish the following immediate tasks: 1) reduce excessive ground speed and correct heading to land "at zeros" on the LZ; (Tab JJ-4) 2) maintain level altitude until reaching 0.15 nm from the LZ;

3) assess MA configuration and performance; 4) decide whether to go-around or continue the approach based on speed and distance from the LZ; and 5) communicate within the aircraft to the MCR and the passengers.

If the MCR decided to go-around, they would also be concerned with the following: 1) go-around route and altitude; 2) a new run-in heading into the wind; 3) enemy threats; 4) terrain considerations; 5) a new TOT; and 6) radio calls to other aircraft in the formation, as well as mission support aircraft.

The DTM data shows the MA made a heading correction to recapture course centerline. (Tab JJ-3 thru JJ-4) Despite the MA's significant deceleration, the DTM data shows, at one half mile from the LZ, the MA was more than twice as fast as the standard LVA speed profile. At 0.4 nm, the MA began a rapid descent prior to reaching the normal glide path descent point (0.15 nm from the LZ). The ground markings provide the evidence that the landing gear was down and locked. (Tab Z-3) Video analysis assessed that the nacelle configuration was nearly vertical. (Tab Z-27, Tab HH-25) There is no evidence that the MCR made a radio call. The absence of a radio call could be explained by the MA's intermittent radio problems. (Tab R-59, Tab V-10.3) However, there was an excited discussion within the cockpit during the last few seconds prior to impact. (Tab V-60.28) It is more likely than not, that this discussion included attempting a go-around.

The greater weight of credible evidence shows that the MCR was task saturated. The priority would have been to fly the aircraft first, then talk on the radio. The complexity required to simultaneously slow down and maintain altitude during this aggressive approach further increased the MP's task saturation. This task saturation played an important role in the mishap sequence of events.

Distraction The MCP stated that he was confused by the landing zone illumination, he observed during the approach. (Tab V-1.10, V-67.5) The MCP's confusion briefly distracted the MCP from accomplishing normal copilot duties. These duties included monitoring the altitude, speed, and aircraft performance parameters. The preponderance of the evidence indicates that the MCP's distraction did not help reduce the task saturation of the MP.

Negative transfer Negative transfer occurs when an individual reverts to a highly learned behavior from a previous system, causing mission performance to be degraded. The MCP had a tendency to continually crosscheck outside the MA due to numerous hours flying other aircraft, which rely primarily on visual cues. (Tab G-31) The MCP admitted that his attention to monitoring instruments during the approach was disrupted due to his crosschecking outside the MA. (Tab V-67.26) The greater weight of the credible evidence shows the MCP's previously learned behavior played an important role in reducing his situational awareness during the LVA.

Pressing Pressing is when the individual knowingly commits to a course of action that pushes them and/or their equipment beyond reasonable limits. The 8 SOS had a high standard for mission execution and a strong desire to impress their supported unit. The MCR also wanted to excel during the first combat mission of their deployment. (Tab V-10.16) As the mission unfolded, the MCR mismanaged their TOT. They were late at all en route waypoints. (Tab JJ-3 thru JJ-4, JJ-6) The MP flew a fast and nonstandard approach. It is more likely than not that the

MP was attempting to make the established TOT, which was a key measure of mission success. (Tab JJ-4) The MP intentionally made aggressive control inputs during his LVA.

(4) Aircraft Performance

Unanticipated high rate of descent Video analysis indicated the MA maintained a relatively steady, but high rate of descent, beginning at 0.4 nm from the LZ and 150 feet AGL, until the main landing gear (MLG) impacted the ground. (Tab Z-3, Z-5, Z-27, Tab JJ-4) At one point during the final seven seconds, the descent rate was approximately 1,800 feet per minute. (Tab JJ-4) The normal descent rate during this phase of the approach should have been 200 feet per minute. (Tab V-24.7 thru V-24.8, Tab BB-31)

The high altitude environment, temperature, winds, and the MA's weight, airspeed, and nacelle configuration affected the descent rate. (Tab K-8, Tab R-77, Tab V-13.6, V-60.35, Tab II-6, Tab JJ-11, JJ-16) Simulator flights confirmed that a go-around would have been possible if the descent rate was caught early enough, the pilot performed appropriate control inputs, and the engines were performing normally. (Tab JJ-11 thru JJ-17) The preponderance of the evidence supports the conclusion that the MA's high rate of descent was abnormal for this phase of the LVA.

Engine power loss A critical question in this investigation was whether an engine power loss played an important role in the sequence of events. I determined by a preponderance of the evidence that the following facts indicate that the MA experienced engine power loss after the one minute call: 1) location and characteristics of landing gear ground markings; (Tab Z-3, Z-5) 2) video analysis of proprotor revolutions per minute (RPM); (Tab HH-25 thru HH-31) 3) analysis of the proprotor ground strikes; (Tab HH-25 thru HH-31) 4) MA smoke, heat, and/or mist emissions captured on video; (Tab Z-27) 5) engine performance degradation; (Tab D-4, Tab U-5 thru U-6, Tab V-59.3, Tab BB-64, Tab II-3, II-52) 6) aircraft computer generated voice warnings; (Tab V-60.22 thru V-60.23, V-60.40) and 7) excited cockpit conversation and rapid countdown. (Tab V-20.4, V-60.36 thru V-60.37)

Although fast and descending quickly, the greater weight of credible evidence indicates that the MP had sufficient time to evaluate and select a landing location just past three deep wadis. Close review of the A-10 video shows that the MP adjusted the MA's pitch attitude and glide path to land beyond the last wadi. (Tab Z-27) Without these adjustments, the MA's initial impact would have been catastrophic.

The greater weight of credible evidence shows that the MP applied left rudder in order to straighten the MA by approximately eight degrees to compensate for the right quartering tailwind. (Tab J-10 thru J-22, Tab Z-3, Z-5, Tab JJ-4) The ground markings would have looked different if that correction had not been applied. The nose gear impact would have been approximately three feet to the right of center. (Tab Z-3, Z-5) Additionally, the greater weight of credible evidence shows that the MP slowed the rate of descent before touchdown. The touchdown was smooth enough to leave the ramp, MLG tires and doors, and the underside intact. (Tab R-23, Tab V-7.35) The absence of large impressions in the sand, at the initial impact point, indicates an intentional, perfectly executed, and straight, roll-on landing. (Tab Z-3, Z-5) The greater weight of credible evidence shows the MP would have only executed a roll-on landing if he believed the MA did not have sufficient power to execute a go-around.

Analysis of proprotor speed (Nr) during the last seconds of flight showed that the Nr was abnormally low. (Tab HH-25 thru HH-31, Tab II-59) Also, analysis of the proprotor blade strike markings on the ground corroborated that the Nr was abnormally low when the MA flipped. I considered the margin of error while evaluating the validity of the Nr percentages. Reduced Nr produces less lift and is an indication that the MA's engines were not operating normally.

Close analysis of video indicates that there is an unidentified contrail type emission from the MA during the last 17 seconds of flight. (Tab Z-27, Tab HH-26, Tab II-59) The greater weight of credible evidence indicates that the abnormal and intermittent emission could be heat or fuel mist from an attempted engine auto-relight, or smoke.

I considered engine percent performance, which was last measured on 6 April 2010 (99.5% for the left engine and 95.3% for the right engine). The MA performed four austere landings, including one with a left engine air particle separator failure, after that 6 April 2010 measurement. (Tab D-4, Tab U-5 thru U-6, Tab V-59.3, Tab BB-64, Tab II-3, II-52) Degraded engines could have led to engine failure, surge/stall or insufficient power when a high power demand was required. I determined, by the greater weight of credible evidence, that one or both of the MA's engines was degraded below acceptable standards.

The MTS indicated that he heard aircraft computer generated voice warnings after the MA impacted the ground. (Tab V-60.22 thru V-60.23, V-60.40) After considering all the possible warnings, I concluded by a greater weight of credible evidence that the following malfunctions could have triggered these voice warnings: rotor RPM (Nr) low and engine failure.

The MP had a reputation for remaining calm under pressure. (Tab V-8.6, V-17.14) The MTS heard an excited cockpit discussion during the approach between the MP and another cockpit crew member. (Tab V-60.28, V-60.36 thru V-60.37, V-64.16 thru V-64.19, V-72.1) A passenger that was monitoring the intercom on the MA also indicated that he heard a rapid countdown prior to impact. (Tab V-20.4) The greater weight of credible evidence shows that the excited conversation was between the MP and the mishap flight engineer (MFE) after the "one minute" call. The excited conversation and the countdown show they were aware of their descent rate, attempting to correct it, but unable to do so, because of abnormal engine response.

d. Discussion of Opinion

There is a preponderance of the evidence that indicates mission execution, environmental conditions, and human factors degraded the MCR's performance and played a direct role in the sequence of events. However, they do not provide a complete explanation or account for all evidence uncovered during this investigation. I determined that only an aircraft performance issue could completely account for the MP's decision to execute a roll-on landing. During a rapid descent, it is unlikely that this very experienced and competent MP would have chosen to execute a roll-on landing on rough terrain if he had power available to go-around and set up for another approach. The MP had the time to make a near perfect roll-on landing; therefore, it seems logical that the MP would also have had enough time to apply full power with the TCL and go-around. It is unlikely that the MP would apply less than full TCL power when attempting to arrest a rapid descent rate. If the MP applied full TCL power, but applied it too late to prevent impact, then the ground markings and subsequent crash sequence would have been noticeably different. The roll-on landing made by the MP was remarkable by any measure.

Although not a factor in causing the mishap, the presence of the drainage ditch and collapse of the nose landing gear increased the severity of damage and injuries during the crash sequence. If the nose gear had not collapsed and/or the MA had not impacted the drainage ditch, the MA likely would have remained upright and the injuries and damage would have been less severe.

The absence of the Flight Incident Recorder, the Vibration Structural Life and Engine Diagnostics control unit, and the right engine prevented the board from obtaining clear and convincing evidence of the cause of this mishap.

Donald D. Harvel

25 August 2010

DONALD D. HARVEL
Brigadier General, USAF
President, Accident Investigation Board

INDEX OF TABS